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CONTENTS

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PROBLEMS OF GEOGRAPHIC INFLUENCE[1]

ALBERT PERRY BRIGHAM

CONTENTS

IMPORTANCE OF GEOGRAPHIC INFLUENCE.—We deal here with the heart of geography. The ties, infinite in number, which bind life to the earth lead surely up to man. No other phase of the subject is so insistent and so appealing as the earth's influence upon our kind. The plant and animal world joins itself to our physical habitat to enrich our environment and multiply our problems. The first members of this Association came into it from the field of geology, and these men, from meeting to meeting and from year to year, have marched steadily up toward the human goal of our science. In Mr. Roorbach's recent symposium on "The Trend of Modern Geography,"[2] by far the larger number directed their call for research toward the field of geographic influence. Whether we speak of influence, or response, or adjustment, matters little. Terminology will grow unbidden if we are exact in our thinking.

Here lies the weight of our theme. We all have a duty to perform in view of the ill-founded and doubtful conclusions too often set forth, and in view of the vast extent of the unknown in this field. The factors of influence are not carefully isolated. What these forces really do and how they do it are not shown. Ripley holds it certain "that the immediate future of this science will depend upon the definiteness with which its conclusions are stated and illustrated."[3] The rich and sometimes noble and rousing periods of Ratzel leave us often in the jungle of thought. But he made a trail in the jungle, and we who follow the trail may not blame him for unexplored corners of the forest. What Ratzel thinks about definite knowledge appears in his criticism of the so-called "climatic philosophers."[4] Here, too, Brunhes adds his call for precision: "How does the climate influence us? . . . . it is just as necessary here, as elsewhere, perhaps more necessary, to rejuvenate current assumptions by analysing them,

[1] Presidential Address read at the eleventh annual meeting of the Association, Chicago, December 30, 1914.

[2] *Bull. Amer. Geogr. Soc.*, XLVI, 801-16.

[3] *Pol. Sci. Quar.*, X, 640.

[4] *Anthropogeographie*, I, 83-84.

for they are far too slipshod and superficial."[1] This call for definiteness presses on every student of geographic influence, be the phase climatic or other. It is not that we can draw mathematical conclusions in any science of man, but sharp eyes and good logic will at least lift us from chaos to order.

We are thus under bond to work this field for the perfection of essential geography. But we owe a further debt, or rather, there is a mutual exchange of help in which we must not fail of our part. Geography offers help and co-operation to all sciences that deal with man—anthropology, ethnology, history, sociology, economics, psychology, and comparative religion—and from each of these geography will gather data for its own perfecting.

The historian, for example, needs from the geographer a fuller knowledge of environmental working, and the geographer receives in turn much from the historian. The old geography knew little of the causal and historical, and some of the old history might just as well have been staged on a flat platform projected into the interplanetary ether.

If history is to strike deep roots into the earth, if it is to set forth with full discernment the molding, moods, motives, and movements of men, the historian will need help from the geographer; and the historian, skeptical of generalizations that are too easy and scorning overstatement, will respond with open hand to every real offering of the geographer.

When geography was poorer than today, Parkman wrote the human story out of its environment. James Bryce has always and without stint placed geography in the running with historical movements. And if the generalizations of Bryce, like those of Ratzel, are sometimes tinged with vagueness, let us blame, not the historian of broad outlook, but the geographer whose work is yet in arrears. Other examples are not wanting. Winsor, in dedicating his *Mississippi Basin* to Mr. Markham, then president of the Royal Geographical Society, writes of environment: "I would not say that there are not other compelling influences; but no other control is so steady."[2]

Mr. Edward John Payne has written a *History of the New World Called America*. Being no historian, I do not know the craft's estimate of that work, but I am astounded at the author's deep and broad knowledge of environment in the lands whose story he tells. The surface, the climate, the possibilities of cereal production and of the domestication of certain animals, appear in suchwise in relation to the early civilization of America, to the arts and habits of its people, as to stir the geographer to admiration. Whether all of Payne's conclusions stand fire or not, he gives an example of effort aiming at precision. This is a call to every geographer. The geographic atmosphere in Professor Turner's story of our North Central West is known to us, and Professor J. L. Myres, reaching at once broadly

[1] "Inaugural Lecture," *Scot. Geogr. Mag.*, XXIX, 312.

[2] *Mississippi Basin*, following the title-page.

into the fields of classic lore, anthropology, and geography, is, in his person and work, living testimony to the importance of our anthropogeographic task and to the hopefulness that lies in our attempting it.

Some historical writers are influenced little if at all by the study of the earth and lower life as elements of human environment. Even some volumes professing to deal with the geographic foundation of history fail of their goal, and one preface affirms that "the general physiography of North America is familiar enough to readers." This, I am sure, is quite too rosy a view of the geographic situation. But I cite the limitations of some histories in no mood of criticism. Let every man build the wall over against his own house. What of assured fact or proven principle we put before the historian he has neither the will nor the power to escape. Our light is in no danger of being put under a bushel. But we have good need to see that it is lighted.

Who can show me a good human geography of Greece? If there be such a work, should it be possible for a historian of Greece to liken Asia Minor and Egypt to enormous jaws about to swallow Cyprus; to describe the Ægean and Adriatic as *fiords;* to liken Southern Europe to a mastodon, Greece being a leg; to call Greece with its mountains, spurs, and bays, a skeletonized leaf; to fill the peninsula with tiers, storeys, waists, claws, wheels, threads, and tongues, and leave you not knowing whether this poor little country is a house of many rooms or a spider with sprawling limbs? But we are most gravely assured that the geography of Greece had results upon its history, and diversity of states, formed by diversity of surface, is the lone geographic captive shut up in this dark closet!

If we turn to sociology we meet insistence on the importance of environment. Let us take Giddings' definition, that "sociology is an attempt to account for the origin, growth, structure, and activities of society by the operation of physical, vital, and psychical causes, working together in the process of evolution." Or we may cite the utterance of Small, that "this force is incessant, ... it is powerful, ... it is a factor which may never be ignored."[1] Yet Dr. Small in an extended chapter on environment mentions geography but once, and then not as a science which might contribute to sociology. Professor Ridgeway[2] thinks that failure fully to recognize man as controlled by the laws of the animal kingdom leads to maladministration of alien races and blunders in social legislation. He says further, "As physical characteristics are in the main the result of environment, social institutions and religious ideas are no less the product of environment." And again, any attempt to eradicate political and legal institutions of an equatorial race "will be but vain, for these institutions are as much part of the land as are its climate, its soil, its fauna, and its

[1] *General Sociology*, 417.

[2] "The Application of Zoölogical Laws to Man," *Brit. Asso. Adv. Sci.*, Dublin, 1908, 832–47.

flora." Ripley, in reviewing the second volume of Ratzel's anthropogeography, criticizes the author for neglecting acclimatization, considering its importance in social theory, and in view of the fact that theories of race dispersion turn upon our judgment in this matter. Perhaps the real state of the case is seen in the appearance not long ago of a serious and careful volume on the development of western civilization, which nevertheless exhibits an utter dearth of geographic data and principles.

We are safe then in saying that most authorities in these sciences of man recognize environment as fundamental, but the greater part, in a sort of absolution of conscience, name the subject and take leave of it.

We need not therefore expect the historians or the sociologists to develop in any full way the principles of environmental action. They admit the need of these principles, but have not the time, perhaps not the will, to develop them. It remains for us to put content into the word environment, so that it cannot be overlooked or slighted, and so that its meaning may become available in plain terms to all.

In his *Racial Geography of Europe*, Ripley asserts that, "Today geography stands ready to serve as an introduction as well as a corrective to the scientific study of human society." This was written about twenty years ago, and yet it is today not so valid or truthful a statement as we could desire it to be. Our convictions are in the right place and much has been done, but we still suffer from a dearth of limited, local, special, and proven data, and a surplus of generalizations announced with the enthusiasm of fresh discovery, or rediscovery, unsupported by adequate evidence. We are subject to Marett's criticism of certain generalizations of Ratzel and La Play—"too pretty to be true."[1] We are awaking to the importance of our field and this is well, but it is equally important to make haste slowly and to give human geography a content satisfying to ourselves and convincing to our fellow-workers in adjoining fields.

Difficulties of the Subject.—The pursuit of our theme is as difficult as it is important. Professor Cramb in a recent book[2] comments on the causal idea so common in our modern thought about history. His word is equally good for us. "In man's history," he says, "nothing is more difficult than to attain to something like a just conception of a true cause." Universality and necessity are the criteria which he proposes. A stiff application of these principles would be a tonic for some geographical theorizing.

Here is an individual, X. What is he? He is first a bundle of anatomical characters. How did he get them? Why is he different in these matters from some other man? A single example will show how little we know. Professor Boas well says that "haphazard applications of unproved though possible theories cannot serve as proof of the effectiveness of selection or environment in modifying types."[3] He calls for comparison

[1] Marett, R. R.: *Anthropology*, 98.

[2] *Germany and England*, 113.

[3] *The Mind of Primitive Man*, 52.

of parents of one environment with their children reared in another. He has made such investigation upon children of immigrants in New York City and concludes that distinct changes, as of head form, took place.[1] He has done well, no doubt, all that one piece of investigation permitted. But he does not analyze the factors of change nor show what any factor does. Alongside of these apparent changes in one generation we may put an opinion of Professor Myres, who, referring to a common belief that Alpine man originated in the Alpine region in response to environment, states his conviction that the time since the glacial period would not suffice for so great a change of head form.[2] Lester F. Ward is equally confident that "there has been no important organic change in man during historic time."[3]

Our individual also embodies physiological and psychical activities which are affected by environment. Here the problem is immensely involved, for, as Brinton says, psychical development depends less on natural surroundings than on a plexus of relations of each man with many others.

Natural environment includes first the physical—soil, water, minerals, land form, temperature, moisture in the air, light, electricity, and all operative on an earth in interplanetary relation to the sun. Then is added the animal and plant environment, whose daily pressure on the individual and the group has held in no small way the destinies of civilization. Interwrought with all these natural forces are the human-social factors, ever more powerful since the dawn of history. Thus there is a total of infinitely variable factors producing infinitely diverse results upon the body and mind.

The environment of this day and hour is perplexing enough, but environments change; and man exchanges one environment for another. The steady drive of our environment in its daily flux is replaced by the shock of a new environment entered in a day or a night or gained by long voyages across the sea. The sum of a man's heredity goes out into his new sphere with him. But how much of this is primal and persistent and how much can be shifted like a garment? The heredity doctors have not answered this question and geographers should have a care. It is a wholesome corrective to remember the number of our possible ancestors. According to Boas,[4] an Eskimo could not have so many as you or I. Royal families share this limitation with the polar man, and one European monarch, it is said, has in the past twelve generations only the meager outfit of 533 ancestors out of a theoretical 4,096. We, however, belonging to a large population of unstable habits, might have in twenty generations more

[1] "Changes in Bodily Form of Descendants of Immigrants," *Sen. Doc. 208, 61 Cong., 2d Sess.*, Washington, D.C., 1910.

[2] "The Alpine Races in Europe," *Geogr. Journ.*, XXVIII, 538.

[3] *Pure Sociology*, 17.

[4] *The Mind of Primitive Man*, 84–88.

than a million each. We are too complex to come to an easy reckoning about ourselves.

By our social memory we carry the old environment into the new and thus we "compound"[1] environments, and this ends in making environment coextensive with the world. The universality of modern environment for any civilized man appears in our commercial interchange and speaks to us in a war whose center is in Europe, whose circle takes in the world.

Ratzel in showing how Christianity conquered its realm, not as direct from Palestine, but as modified on its way through Egypt, Greece, and Rome, has given us a good example of such compounding of environments.[2] Geographers have by no means been blind to the difficulty of anthropic problems. Brunhes warns us that truth in geographic relations of man is approximate, and that to claim it as exact is to be unscientific.[3] "The outstanding psychological fact then is the antithesis of a rigid fatalistic determination of human acts by climate and soil."[4] And he then cites what he calls "antinomies"—frontier, urban, racial, and social. Ratzel has a most instructive passage on sources of error due to the neglect of middle members lying between visible workings and their remote causes; the inclination to take a direct line instead of the roundabout way of mediate working causes. This leads either to false results or to hopelessness of reaching the truth.[5]

Professor Myres in the closing lines of his little book, *The Dawn of History*, admits and emphasizes the vagueness of results in trying to estimate the relations of history, geography, and biology. But his final word is of good cheer: "If the reader is moved to complain with that other, 'I see men as trees walking,' let him remember that he who said that was well on the way to 'see every man clearly.'"

Thus far our notice of our difficulties has been general. Let us look at the questions of race. "Race is the key to history—what is the key to race?" Thus Griffis inscribes the title-page to a volume on Japan. In estimating the force of a given environment on a given period, how much shall we allow for race? But we must go back of that. How did environment go into the making of race? But suppose we are not sure what a race is and cannot with any agreement analyze and classify present races. Authorities agree neither upon race nor upon the efficiency of race in relation to environment. Thus one authority assigns a race cause for the higher status of longheads as compared with broadheads in certain parts of France. The longheads have more wealth and pay more taxes than their brachycephalic countrymen. Is this really a racial result? Or is it due to a fortunate occupation of richer lands, bringing in its train the higher pro-

[1] Marett, *op. cit.*, 122–23.

[2] *Anthropogeographie*, I, 175.

[3] "Inaugural Lecture," *Scot. Geogr. Mag.*, XXIX, 362–63.

[4] *Ibid.*, 367.

[5] *Op. cit.*, I, 54.

fessional and social status and the urban tendencies of the northern blonds? The criteria of necessity and universality need to be pressed home.

The present writer has difficulty, being a layman, in understanding the ethnologists when they classify races. It is increasing to one's comfort, therefore, and saving to self-respect to find a member of the anthropological fraternity saying of the development of races that it is "immensely difficult to separate the effects of various factors," and that "it is not edifying to look at half a dozen books upon the races of mankind, and find half a dozen accounts of their relationships having scarcely a single statement in common. Far better to face the fact that race still baffles us almost completely."[1]

We may add a further observation, that much in this field depends upon paleogeography if we are to decipher the origin and migration of races. But here, as Marett says, is a rather kaleidoscopic science, for the continents and bridges which it calls up out of the ocean have a way of crumbling.

Let us illustrate by the so-called Aryan question. It used to be an item in the ethnological creed that most European peoples, using languages of cognate features, came thither from Central Asia by the way of India. But many years ago now it was shown that common language did not prove race kinship. Nor do names of trees and other plants suffice to trace migrations, for men change the names of their trees, and floras migrate in the long marches of time. It has been remarked that if we had no historical knowledge to the contrary, *tobacco* and *potato* might be taken as parts of a European tongue, rather than a loan from the Caribbean natives.

So come the measurer and the calipers in place of the linguist and set up the physical criteria of head form, stature, and color, and put in place of a comfortable and discredited generalization the chaos of opinion which is often the precursor to more fixed and defensible conclusions. But such conclusions have not yet been reached. So uncertain is the status of the problem that one writer on the sources of the Germanic invasions says that while some put the origin in Africa, others trace racial differences to environment, and others fall into skepticism about the whole matter.[2] This author thinks the Germans are diverse, as a Roman might be anything from York to New Carthage, Corinth, or Damascus.

Brinton holds that the origin of this so-called Indo-European group was in the west, the central Celtic tribes moving from the Atlantic region through the Alps to the Danube, a southern series of offshoots peopling the Mediterranean, and the northern, moving southward and eastward from primitive seats on the North and Baltic seas.[3] Another authority thinks with Sergi and Keane that the Mediterranean stock came from Africa and

[1] Marett, *op. cit.*, 61.

[2] Hayes, C. H.: "Sources of the Germanic Invasions," *Studies in Hist. and Pub. Law*, XXXIII, 14–15.

[3] *Races and Peoples*, 151–52.

that the Dolicho-blond developed after the passage to Europe and the initiation of the Mediterranean water barrier.[1]

Ridgeway,[2] on the other hand, makes two non-Aryan races in Europe, Alpine and neolithic, overrun by two Aryan races, once thought to have come from Hindu Kush, now believed to have originated in upper Central Europe. He argues that to follow Sergi in making the Mediterranean race non-Aryan "leaves out of sight the effects of environment in changing racial types, and that too in no long time." He cites the cases of the Boers in Africa and of New World natives changing their latitude. There was gradual change from the short, dark men of Southern Europe to the tall blonds of the Baltic. This means more than intercrossing, and raises suspicions of constantly working climatic influence. He thinks environment the chief factor in stature and pigmentation. Attention to other animals, in Ridgeway's view, demonstrates this doctrine. He cites the white hares and bears and the tendency of the ptarmigan and the horse to turn white in winter. The horse is cited as shown in varieties from Northern Asia to the Cape of Good Hope, and this writer concludes that environment is powerful, not only in colorations, but in osteology, and that these changes may be very rapid. The blond Berbers are believed to owe their qualities, not to mixing with Vandals and Goths, but to being cradled in a cool mountain region. The fair-haired people have poured for centuries across the Alps and yet hold their own only in the north of Italy. Woodruff does not think they were darkened, but that natural selection eliminated them because they went beyond their latitude range. Homo Alpinus is held by different authors as Aryan or as Mongolian from Asia, and as having evolved his brachycephalic character on European soil.

Marett, referring to Ridgeway, thinks he overrates environment, but admits it as premature to affirm or deny that, in the *very long run*, round-headedness goes with a mountain life.[3]

To add other items of opinion, confirming the conviction that much fruit has set, but few specimens have ripened, Marett places in North Africa the "original hotbed"[4] of the Mediterranean race, who in neolithic times colonized the north shore of the Mediterranean and passed by the warm Atlantic as far as Scotland. The same author, keeping close to cover, says that it is now fashionable to place the Teutonic home in Northeastern Europe, though he regards it as still something of a mystery. The Scandinavian origin of European peoples is held by some,[5] while J. L. Myres shows the affinity of boreal and Mediterranean man and suggests their Euro-African origin,[6] and Gray's discussion of Myres's paper emphasizes the swift action of environment.[7]

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[1] Viblen: "The Mutation Theory and the Blond Race," *Journ. Race Devel.*, III, 491–95.

[2] "President's Address," *Brit. Assoc. Adv. Sci.*, Dublin, 1908, 832–47.

[3] *Op. cit.*, 107. [4] *Ibid.*, 104.

[5] Richard: *History of German Civilization*, II.

[6] "The Alpine Races in Europe," *Geogr. Journ.*, XXVIII, 537.

[7] *Ibid.*, 555–56.

Altogether it is hardly exaggeration to say that you can find authority for placing the breeding-grounds of the European peoples in North Africa, in Central Asia, or in any part of Europe, and for sending their wandering progeny in any direction of the compass, with any kind of racial mixture, or linguistic evolution, and with every possible shade of efficiency or inefficiency on the part of environment.

But suppose the Aryan business cleared up, there would remain earlier problems of paleolithic differentiation and the prolonged twilight journey of man. And suppose we had threaded our way, geological, ethnographical, linguistic, and geographic, down through the differentiations and mixtures and migrations until we have the Teuton and the Celt in Northern Europe and the British Isles; are our troubles past? Let us see.

You would trace the evolution of the American, as affected by environment. Where will you begin? Not in New England or Virginia. Not altogether in old England. Not altogether in Teutonic Europe. Before we got through with the American we might like to cover all Europe with the network of our inquiry. But we cannot move too broadly; let us turn to the British Isles. There are still the progeny of the pre-Celts of neolithic age. There came at least three types of Celt—the Gael, the Briton, and the Belgae. Roman invasion and rule followed, and in due time the Christian religion. Next came the Angles and Saxons and Jutes from across the North Sea, a new deluge of paganism and a new contribution of racial traits bred in the long past. One would like to know how that old North Sea Teuton differed, fifteen centuries ago, from the Baltic Sea Teuton of the Prussian plain. Was it in the latter's great strain of Slavic blood, or were there other factors? When and where did the present sum of difference between Prussian and Englishman begin to emerge? At any rate, Jutland, Schleswig-Holstein, and the lowlands of the Elbe were poured into our ancestry and were Christianized.

In the eighth century the Viking rovers came across the North Sea with fresh cargoes of vigor and paganism. The Rhine, the Scheldt, the Seine, and the Loire, as well as Britain, felt their power. "From the fury of the Northmen, save us, Lord," runs an old litany. But pirate and robber though he was, here was an element of selection that must not be disregarded. Norway, Sweden, and Denmark, says Greene, "were being brought at this time into more settled order by a series of great sovereigns, and the bolder spirits who would not submit to their rule were driven into the sea and embraced a life of piracy and war." But there had been bred into them "in a land that is one-third water and one-third mountain, where winter lasts six months in the year, endurance, ingenuity, and daring."

In two or three centuries more followed the Norman Conquest, in which the Viking brought to England all that he had taken on and taken in of French life. There follows the further co-ordination of neolithic, Celtic, Teutonic, and Norse men for five and a half centuries, until the early

decades of the seventeenth century and the beginnings of British settlement in America. And this was a selective migration whose story cannot be told here, and has never been so fully told as the student of environment might desire. Suffice it to add that no mere paragraph can tell us what kind of people came to Massachusetts or Virginia. Religious, economic, and political changes in England, plus the attractions of a fresh world, brought across the sea the elements that have been formative in American life. American environment has not developed all the qualities which we consider as distinctively or typically American.

But in New England, and on the Hudson, the Delaware, and the James, new physical and social pressures began to wield their power. After some generations in this environment, in the eighteenth century a new flow began through the passes of the Appalachians. To Timothy Dwight is ascribed the view that thus New England was rid of her restless and insubordinate spirits. Another interpretation is that the best and most progressive men went because they did not like the rule of the Congregational clergy. At any rate it was another selective migration, by which picked families went into a new environment. Turner is our best authority for what the environment of the Middle West made out of the immigrant from the East. It would be easy to show, I think, that in spite of what might seem predominating mixtures of Continental European migration, New England still pervades Wisconsin, that the New England mind was more powerful than the new environment, important as that was, just as the Puritan mind was more powerful than the New England environment.

The selective emigration moved on by prairie schooner and transcontinental railway to the Rocky Mountains, the intermontane plateaus, and the Pacific Coast. Here are mountains, deserts, mines, giant forests, irrigation, and a new ocean. Whence came the Californian? From New England, Ohio, Iowa, Kansas, Colorado. Is that all? Every one of the following regions is there, with 5,000 to 200,000 representatives: Germany, Ireland, England, Canada, Italy, Mexico, Russia, Scotland, Sweden, Switzerland, Portugal, Norway, France, Denmark, Austria, Wales, Turkey, Spain, Greece, China, Japan, Islands of the Atlantic, Australia. The German, Canadian, Englishman, Spaniard, and Russian that wanted to be or do something new, are there. And it is a compelling environment of sky and mountain, ocean and plain, forest and desert, mine and field. Professor Royce, a native Californian, thinks the typical character there is a combination of strength and weakness, with wandering in the blood, lack of social responsibility, recognition of no barriers, desire for sudden wealth, love of difficulty, unaccented love of home, with more love of fulness of life than reverence for the relations of life.[1]

One more picture of this western life must suffice. It is by a journalist, and portrays the American of the far Northwest, where New England and the "Mayflower" appear not, whose men "followed the Missouri from

[1] Royce, J.: *California*, 499–500.

Kentucky, Indiana, Missouri, and Arkansas; tall, big-boned, and stalwart, self-assertive, nervous, quick in action, acting before they think and thinking mainly of themselves, their European origin so far behind them that they know nothing of it. Their grandfathers had forgotten it. In a word they are distinctly, decidedly, pugnaciously, and absolutely American."[1] Making what allowance you will for Ralph's exuberant rhetoric, and Royce's habit of philosophizing, better to be solved in the twenty-first century than today, is the problem of the function of environment in shaping American life. As we have seen in this sketch, the geographer will not work alone—the historian, the sociologist, and the philosopher will take a hand.

Its a long way from the primitive man to the differentiation of the white race; from the white beginnings to Britain, Norway, and Normandy; from England to California and Puget Sound. Along this ancient and devious path our ignorance of the inner laws of human development is appalling. We see man, and earth, something called race, race continuity, one physical environment after another, human environments with innumerable mixtures of blood, in infinitely various compounds, in the grand march of humanity to one world center after another. The result, to carry out our illustration still, is the Pacific Coast man—domestic, industrial, political, social, moral. It will take cautious steps and many torches to pick our way back along the road by which he came.

Let us take another example in emphasis of the difficulties which beset us—an analysis of the causes of Japanese character. Mental alertness has been asserted to be the chief trait of the Japanese. This must have originated in accordance with biological laws, in spontaneous variation, in mixture of races, or in environment, or, we might add, by a combination of these. It is tentatively held that however this quality arose, it has been preserved by environment: first, by insularity, giving familiarity with the sea, saving from wars, intermixtures, and invasions, in distinction from a continental land, like China; secondly, by physical features, affording small areas of cultivation, promoting industry, a land of such richness as to give certainty of reward, without drought or flood to destroy the prudent as well as the thriftless. Thirdly, there comes climate, following a supposed law that the progressive lands are in the cyclonic domain of the Temperate Zone.

This seems simple, interesting, and suggestive, but is it true? Is mental alertness the chief trait in Japanese efficiency? Droppers, sometime professor in the University of Tokyo, thinks the secret of success is in the structure of society, devotion to family life, or to tribe and nation, the corporate versus the individualistic.[2] Dyer emphasizes community, but denies that the main ability is in imitation. Loyalty and intellectual

[1] Ralph, J.: *Our Great West*, 141–42. Quoted in Abstract.

[2] "The Secret of Japanese Success," *Journ. Race Dev.*, II, 424.

ability are the bases of achievement. Another authority marks the Japanese as sober, intelligent, enduring, patient, industrious, polite, skilful, ready to assimilate, not devoid of original genius.[1] Yet another says that he is patient, persistent, cheerful, versatile, quick-witted, enterprising, original, imitative, progressive, industrious, artistic, humorous, cleanly, polite, honorable, brave, kind, calm, self-contained.[2] Whether any good human qualities have been left out of these catalogues we do not know, but we are at least left in doubt as to what the main national trait is.

But suppose it is mental alertness. Would insularity make it or keep it? Miss Semple avers that insularity breeds conservatism, a quality that does not seem to be indissolubly tied to alertness. Insularity may give familiarity with the sea, but perhaps not greater than is true of the Dutch, who are not insular, and we do not think of the Dutch as distinctively alert. Insularity has not kept Japan free from invasion, though there have been periods of seclusion. And the modern Japanese are "a very mixed people," Mongolian, Caucasian, Malay, and some say an infiltration of Negrito. If insularity breeds alertness, what other factors have apparently swamped this tendency in Madagascar, Iceland, Sicily, Cuba, and Hawaii?

Nor can we be sure of the effect of small areas of rich cultivation and certain reward. Industry we can predict and a degree of comfort, but can we say more? Why not as well expect the Belgian farmer or the farmer of the Paris Basin or the County of Norfolk to be mentally alert? Moreover, most Japanese are in a low state. "We imagine them [the Japanese] as intellectually homogeneous," but there are "five million highly cultivated people and nine times as many of lower type . . . . the mighty mass still pagan, stolid, low in the scale of evolution."[3]

This little empire is indeed a good place in the Temperate Zone, and so are China, Switzerland, Spain, Austria-Hungary, Germany, France, and too many others to make the criterion of distinctive value. The inference for precise, detailed, and prolonged research need not be elaborated.

Related Sciences.—We have already spoken of certain related sciences as supplying motives to the human geographer. We turn now to examine the geographer's proper sphere of activity in relation to these sciences.

Our references to the race problem might seem superfluous, for if this field belongs essentially to the anthropologists, what right has the geographer there? Here we seem at once to need a definition of geography. But the present writer will not try to go where angels have trod with devious and faltering steps. Sometime we shall have a definition of geography, but not now. Meanwhile we have enough to do, and if we are

[1] Dingelstadt, V.: "Ruling Nations," *Scot. Geogr. Mag.*, XXVII, 305.

[2] Art. "Japan," *New Int. Ency.*, X, 335.

[3] Griffis, W. E.: *The Japanese Nation in Evolution*, 271, 386, 389–90.

reviled as devotees of patchwork, as having no real science, we bear it with serenity.

I do not know of anyone who proposes to rule us out of the human sphere, and shut us up to the physical. If I can get my foot on what Brunhes calls the "humanized surface"[1] of our planet, I am content. I shall have enough to do without quarreling with my neighbor or resenting anything he may say to me. Brunhes also says that we are where roads meet, with facts from many sources; that we must not be a bazaar for retailing everything, but have our own domain and commit no trespasses. What the limits of this field are is not so clear, but why trouble about it, when no science has a fenced domain?

Ratzel makes a sweeping criticism of Buckle when he says that *evolution* is unspoken by him.[2] The great geographical philosopher of Leipzig made it forever imperative for us to "go back unto the past." He speaks of differentiation, of bequeathed influences, of the migration of developed traits—he never lets you doubt that he is moving in the realm of Darwin. So the geographer, if he touches man at all, and the more if he opens the question of geographic influence, must be in daily contact with the principles of biological evolution, so far as the specialists have mastered them. I will not try to say how far he may supply useful data to the biologist. Sure it is that human anatomy, physiology, and psychology must be relied upon for light on the early (as well as late) stages of mankind. Should not this field be turned over to the anthropologist?

The first answer is that so far as environmental factors are concerned, the geographer alone is responsible for the knowledge of the total physical complex which the earth affords. But when this comprehensive survey of the physical geography has been supplied, do not the geographer's duties, and even his rights, cease? If so, and if we must leave the action of environment to the anthropologist, to what kind of an anthropologist? The somatologist, perhaps. The somatologist studies the natural history of the body. This is highly important, but it is only one point of view. He also studies man in his physiological development, but this is also partial. Your anthropologist may be primarily a psychologist, a philologist, or a student of early arts or of comparative religion. Or he may be an ethnologist studying the physical features, mental traits, linguistics, practical arts, legends, and religions of a single tribe or people.

To which one of these will you look for a world-view of the influence of environment on early or half-developed man? For your answer go through all the reports and books of the anthropologists, rich as they are, and tell me the result. In the nature of the case, the anthropologist, even if he could command all the departments of his own science, is not in a position to organize the principles of the influence of an earth-wide environment on man. He offers indispensable materials and he may find other unities

[1] *Scot. Geogr. Mag.*, XXIX, 313.

[2] *Op. cit.*, I, 97–98.

in his field, but the inclusive bond of world-environment belongs to the geographer.

Suppose we say that we do not need anthropologists because there are anatomists, physiologists, psychologists, philologists, and students of art and religion. The answer is that anthropology aims at the natural history of man as a whole. The specialists work indeed too often in small and isolated fields, and not always with the causal and comparative principle in full view. But man, the bond, is there, and the science receives its justification. In like manner, why should there be geographers, for there are geologists, meteorologists, oceanographers, astronomers, botanists, and zoölogists? We say because there is no other to organize the data of all these sciences in relation to the whole earth, as we see it and know it.

Taking a like case, there are anthropologists of many sorts, historians of several kinds, sociologists, economists, and technologists in ample variety. Why a human geographer? Because there is no other to exhibit the human kind (not now but in some coming day) in its causal and distributional relation to the earth and its forces, viewed as a unity.

Professor Adams in his presidential address before the American Historical Association manifests a little concern because of the entrance of political science, geography, sociology, and certain other subjects into the arena.[1] But history, conceived on the modern scientific basis, opens so vast a field that collaborating sciences may well be welcome in the task. Equally may the geographer rejoice that every science of man contributes to his own, and that he in turn has something to share.

There need be no hoarding of opportunity where opportunity is infinite, and no quarreling over line fences where none can exist. Professor Turner, referring to economist, geographer, sociologist, and other fellow-workers, has thus broadly expressed the true attitude of the historian: "The historian must so far familiarize himself with the training of his sister subjects that he can at least avail himself of their results and in some reasonable degree master the essential tools of their trade."

No one would accuse Professor Turner of advising overexpansion or superficial endeavor, but he seems to think it possible to be a historian and something more, by virtue of which to be a better historian. So say we of the geographer. Let him be "familiar with the whole earth," as demanded by Ratzel,[2] not in detail, but broadly familiar with causal principles and their regional illustration. Then let him know the methods and results of history, or of sociology, or of anthropology, or of some phase of one of these. Then he can co-operate in that study of environmental influence which must be common ground for all.

All this has its bearing on the higher education, for every human geographer should have his minor studies in some other science of man, and no young historian should be allowed to escape who is not grounded

[1] *Amer. Hist. Rev.*, XIV, 221-36.

[2] "Studies in Political Areas," *Amer. Journ. Soc.*, IV, 302.

in the principles of physical geography and who has not looked through the geographer's eye at the impress made by nature on man.

Sociology is a science which equally with geography has aroused skepticism concerning its right to be called a science. Be that as it may, its devotees occupy ground which stretches into historical territory on the one hand and geographical and anthropological on the other. This is conceded by Small. "The comprehensive science has the task of organizing details which may already have been studied separately by several varieties of scholars."[1] The same author sets forth the influence of nature with an emphasis which if used by the geographer might call down a charge of excessive claim. "Nature sets our tasks, and doles out our wages, and prescribes our working hours, and tells us when and how much we may play or learn or fight or pray. Life is an affair of adjusting ourselves to material, matter-of-fact, inexorable nature."[2] Small does not think we yet have an adequate story of the operation of cosmic laws in determining the course of human development.

Mr. E. C. Hayes, in a paper in the *American Journal of Sociology*,[3] discusses the relation of geography to sociology and the definition and scope of geography. He seems disposed to think that stating the effects of geographic conditions on social phenomena will be an integral part of sociology, but thinks "it will still remain true that no science but geography describes the regions of the earth by bringing together into one description all the various facts separately studied by the different sciences."[4]

It is fair to say that only the geographer can know the physical conditions in a broad and deep way. It is just as fair to expect the sociologist to be superior in the strictly human field. But neither can dismiss the other, nor prescribe a legitimate boundary line of research. And there is always the possibility of a genius equally at home in both fields, scorning all petty frontiers of our so-called sciences, fusing and re-creating the data and conclusions of lesser men, and recording for all time those larger generalizations of which we dream and for which we strive.

After all that can be said on the relations of geography to other subjects, I am content to come back to a confessedly general, but safe and truthful word by James Bryce: "Geography is the point of contact between the sciences of nature taken all together and the branches of inquiry which deal with man and his institutions."

I think it is a sociologist, Ward, who likens the progress of science to the progress of a prairie fire. No doubt he means that it moves irregularly, but surely. The figure is not altogether good, as indeed no figure is, for we do not move with a rush, neither does our going leave a zone of destruction behind. Our work is constructive and slow. Whether the worker be a geographer or bear some longer name is not material. If he have no name at all, let us accept his fact, his principle, in good faith, that

[1] *General Sociology*, 7.
[2] *Ibid.*, 408.
[3] XIV, 371–407.
[4] *Ibid.*, 400.

as workers and half-thoughts come and go, the body of truth gathers volume, order, and power.

FIELDS OF INVESTIGATION.—We come now to the last phase of our discussion, the most important and difficult of all—lines of investigation. What is our present status? It would be a good work if someone would review historically the progress of the idea of environmental influence. Here the barest sketch must be the preliminary to our inquiry.

We may pass by the fragmental notices of ancient and mediaeval writers. Modern seed thoughts are not uncommon, and some harvest could be gathered from the philosophers and literary writers, Hobbes, Montesquieu, Kant, Herder, Hegel, Comte, Taine, and others. Humboldt, Ritter, and Guyot laid the foundations of our modern human geography, and then came Darwin, pointing the road to fruitful study for all the sciences of organic nature and of man. Ratzel, in the spirit of Darwin, kept the unfolding of geography abreast of the progress of anthropology, history, and other human sciences in the last half-century, and now Miss Semple has placed all geographers in her debt in the expansion and precision which she has added to the work of Ratzel.

General works of lesser scope, some of them regional, have appeared in this country and in Europe. Mackinder, Herbertson, Lyde, Chisholm, and others in Great Britain, and Vidal la Blache, Brunhes, Partsch, Penck, and many others on the Continent, have made important contributions. Already we have a large and rapidly growing list of small monographs dealing with limited phases or regions in this country. In America this work is largely the achievement, direct and indirect, of the members of this Association, and the present program is sharp evidence of the force of an impulse that has gathered power among us during the ten years of our co-operative endeavor.

My first hint is in the direction of climatology in its relation to man.[1] Here is a new science, with a growing body of observation, generalization, and record, made available in description and in maps. Climatology is beginning to be appreciated in relation to other fields of physical geography. We begin to value and to express in textbooks the relation of the atmosphere to the origin of land surfaces, glaciers, aridity, and the waves and currents of the sea. We see its functions also in relation to the mineral contents of the earth, and in relation to the origin and use of soil. Even more pronounced is the growth of ideas in relating the atmosphere to fauna and flora, to plant and animal types and societies, to bacteria, and to forests, steppes, and deserts. Involved in all this relation to the inorganic and organic world is an immense indirect influence on man.

There is also direct influence on man, through temperature, varying constitution, variations of pressure, moisture content, movements, optical effects, and sound waves. Professor Channing recognizes climate as the

[1] See G. Brunhes: *Scot. Geogr. Mag.*, XXIX, 312; Dryer, C. R.: *Journ. Geogr.*, XI, 178; Ratzel, *op. cit.*, I, chap. on "Das Klima."

most important of all natural forces in controlling human activity.[1] And we cannot stop short of psychical, social, and economic phases of influence, all tangled in difficult fashion. When the consumptive goes to Colorado for help, and finds it, what has accomplished the result? Is it rarity and increased lung expansion? Is dryness and a non-relaxing quality uppermost? And how much is due to new hope, new effort, fresh scenery, new and glorious land forms, clear skies, gray desert, and new social environment? Let us move, but move cautiously, heeding Professor Ward's emphasis on doubtful elements in the relation of climate to disease. Perhaps there is no subject, unless it be politics, on which men say so much and know so little as about climate.

Geography has a considerable body of good knowledge of climate in relation to modes of living in typical parts of the world. We know that the Eskimo is carnivorous, the tropical savage vegetarian, and that the denizen of temperate latitudes brings both foods to his table. We know that climate has its influence on clothing and shelter, on nomadic and pastoral, agricultural and static, life, and among hunters of the forest. These are all important, but more or less indirect, climatic effects, so well set forth by Herbertson in *Man and His Work*.

But what of direct effects of climate? I hesitate to use the word direct of such activity. Such is our ignorance of the precise efficiency of these forces, that apparent direct agents may turn out to be mediate after all.

How much exact knowledge have we in the field of coloration? Grant that this is mainly a physiological problem, so far as man is concerned. Will it ever be solved, and the results broadly stated, except in collaboration with geography? "Colour almost certainly developed in strict relation to climate. Right away in the back ages we must place the race-making epoch, when the chief bodily differences, including differences in colour, arose amongst men." This is from Marett, and he adds that natural selection had a clear field with the body before mind became the chief factor in survival.

Now how much is definite here? What is this "strict relation" to climate? And what element of climate does the work? Is it heat, or light, or moisture, or a combination of these? What does each climatic factor do, and does it do what it does independently or by the aid of some non-climatic factor? Why is the Malay brown, the Chinaman yellow, the American Indian coppery, and the Negro black? And how do the osteological features and the facial features correlate, if at all, in origin with the color? Here is a vast field. What of assured answer is on record?

Brinton says that climate and food supply are the main causes of the fixation of ethnic traits. He adds that temperature, humidity, and other factors bear directly on the relative activity of lungs, heart, liver, and skin. This seems to come near to the core of things, but no precision is reached,

[1] Channing, Edward: *Students' History of the United States*, 2.

and I suppose cannot be, in the present state of knowledge. Ratzel was not wrong in citing the Negro's dark skin as illustration of the fact that the search for causes goes after hard and deep-rooted things.

The study of the races of Europe teems with conjecture about blonde and brunette, but the physiological basis is wanting. We should like to know whether the Mediterranean longhead is a darkened Teuton, or whether the Teuton is a bleached African. Here is joint work for physiologist, anthropologist, and geographer.

Ward notes the fading of hair, beards, and skins of polar explorers.[1] The same author, leaving open the origin of color, quotes Darwin on the accumulation of color through natural selection and contents himself with the assured fact that color, however obtained, is an advantage in a hot climate. This field therefore is almost unworked. I hesitate to say that the door for research is wide open, but one would hesitate even more to believe that the problem cannot be solved.

Suppose that we leave now these primitive and racial puzzles and come down to possible effects of climate that can be seen and registered in a few generations, if there be such effects. Here is the question of acclimatization and tropical disease—in short, of the white man's burden.

Here again Ward proceeds with instructive caution. It is a complex subject, he says; conclusions are contradictory; curves may be made to show anything. There are many weather elements and there are many other factors, such as sanitation, foods, water, habits, altitude, soil, race, traffic, and other controls. Micro-organisms intervene to make climate largely an indirect influence.[2]

Thus we have a group of problems for the medical observer, but either in him or with him must the geographer share the task whose successful accomplishment affects the destinies of every colonial empire and the ultimate place of the white race. Brinton speaks of the hopelessness of the problem,[3] and Ripley recognizes the importance of it by criticizing Ratzel for inadequate attention to it in the second volume of the *Anthropogeography*.[4] We have an interesting discussion in Woodruff's *Effects of Tropical Light on White Men*. It is for a more competent critic to estimate its value. Some of its generalizations seem too sweeping and too easy to be true. Altogether in this whole field, a field of high practical importance, there has been much sincere effort, but no great harvest.

We want narrower fields of investigation and better-proved results. Only thus will be gathered the data for great generalizations. In this direction we may cite a passage of Hahn on the physiological effects of diminished pressure,[5] and the studies of E. G. Dexter and H. H. Clayton on the sociological effects of climate.

[1] *Climate Considered Especially in Relation to Man*, 216.

[2] *Ibid.*, 180 ff.

[3] *Races and Peoples*, 278–83.

[4] *Pol. Sci. Quar.*, IX, 323.

[5] *Handbook of Climatology* (trans. by Ward), 224 ff.

Let us look at the field of biogeography in relation to man. The distribution of plants and animals as forming large elements in environment cannot fail to involve man and to uncover many interesting relationships. This study is now in a hopeful state of vitality and progress. Our own association has a good number of workers in this field.

A wealth of pertinent facts awaits discovery and co-ordination as regards the coincident distribution of man with plants and animals. Payne, in the history of early America already cited, uses this as a basal principle, showing the migration and presence of organic forms in causal relation to man. Here again, Ripley finds occasion to criticize Ratzel for insufficient attention to the theme. A few suggestive illustrations may be given. Kirchoff in his *Man and Earth*[1] co-ordinates the Mediterranean spread of the Phoenicians with the occurrence of the dye-yielding mollusc. Dr. C. Hart Merriam once surprised the writer by saying that the beaver was the most important fact in early American history. The more one considers this the less one is disposed to consider it as an outburst of a biologist's enthusiasm.

In Hansa days tens of thousands of people dwelt in the peninsula of Schonen, in the towns of Falsterbo and Skanor, at the southwestern tip of Sweden. Today an old church, a few cottages, and a summer hotel make up Falsterbo, while Skanor is a sleepy village of a few hundred people. Why should these throbbing Baltic markets of centuries ago have suddenly declined to insignificant shore villages? Because the herring migrated to other waters. A new harbor has been built at Skanor, and it will be seen whether modern conditions can restore the prosperity which the runaway fish destroyed.

Dr. Scharfetter in a work on the distribution of plants and man sets the Roman boundary in Germany at the edge of the Franconian forest, and cites the fact that the Arabs went wherever the date palm would grow.[2] The practical biologist, such as the agricultural explorer, turns the problem around and shows how to control the distribution of lower life and thus to modify the distribution of man.

Such results must flow from the work of the Department of Botanical Research of the Carnegie Institution, and Dr. McDougal of the Desert Laboratory well sets forth the interrelations of the sciences when he likens the work to the making of a cantilever bridge whose farther ends may rest on chemical, physical, geological, or geographical piers.[3] A good illustration of this finds immediate place in the investigation by Professor Huntington, in western forests, of climatic events.

The climatologist asks for definite climatic effects on man. The ethnologist or sociologist finds traits in man which might have a climatic origin. The geographer wants all that all types of specialist can give him,

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[1] Trans. of *Mensch und Erde*, 30-31.

[2] Paper is noticed in *Scot. Geogr. Mag.*, XXVII, 39-41.

[3] *Ann. Rept. of Director*, 1912.

both in the physical and psychical spheres. Thus we may approach from the point of view of causes or of results and follow down or up the stream of effects.

We have made a hasty survey of two fields of causation, the one physical, the other organic. Let us turn to certain groups of phenomena in the realm of effects or results. The most important and surely the most baffling problems here are in the psychic field. Here the geographer will be peculiarly dependent on workers in sister sciences and the gap may be hard to bridge. Geographers are not as a rule specialists in psychology, and there is no reason to believe that many students in psychic fields are specially versed in geography. If we can offer a stimulus which shall lead these kinds of scholars to struggle up the stream of causality, it may be safer than for us to drift down through rapids and among rocks. But the work ought to be done, and the geographer can at least show its worth and encourage the doing of it.

In this research we are not to think that the earth was all powerful with early man, but is helpless today. Color or other race features may have then been fixed, but this is not all. If there is something in man that is found in every man, wherever he is, he is not thereby released from the pressure of environment. Psychic reaction on nature does not destroy nature's efficiency, but in a degree directs, refines, and uses it. When Professor Lester F. Ward says that "the environment transforms the animal, while man transforms the environment,"[1] he utters but a partial truth. Perhaps he was attracted by rhetorical form, for in a later passage he recovers himself, recognizing the psychic effects of environment, for, "courage, love of liberty, industry and thrift, ingenuity and intelligence, are all developed by contact with restraining influences adapted to stimulating them and not so severe as to check their growth."[2]

If a hard winter is a "great Teutonic institution," if rains, dark skies, and winter have made more serious peoples in the north of Europe than are found along the Mediterranean, if Geikie rightly ascribes the heart of Ossian's poems to nature in the West Highlands,[3] these qualities of environment are pressing on the human spirit today as in neolithic or Celtic time, moderated, perhaps, by modern skill in getting protection from nature, and by greater contact with all the world. We will not deny the assertion of Thomas that "the force of climate and geography is greater in the lower stages of culture and that ideas play an increasing rôle," but we do not know on what ground he makes the further claim that the peculiar cultures of Japan, China, and India were in the first place the results of psychic rather than geographic factors.[4]

There is a beautiful passage in Ratzel which I now commend to those historical and sociological philosophers who think that psychic qualities and powers are released from environmental influence: "If ethnographers

[1] *Pure Sociology*, 16.

[2] *Ibid.*, 58.

[3] Geikie, A.: *Scenery of Scotland*, 407–8.

[4] *Source Book for Social Origins*, 130–31.

utter the view that the development of culture consists in ever-wider release from nature, we may emphasize that the difference between nature and culture folk is to be sought not in degree but in the kind of this connection [*Zusammenhang*] with nature. Culture is freedom from nature not in the sense of complete release, but in that of much wider union. The farmer who gathers his corn in the barn is really as dependent on his ground as the Indian who harvests in swamps wild rice which he did not sow. We do not on the whole become freer from nature while we deeply exploit and study it, we only make ourselves in single cases independent of it, while we multiply the bonds." Not to do Ratzel injustice, it is he who has also called "the spirit of man a completely new phenomenon upon our planet," and has asserted that "No other being [*Wesen*] has worked so permanently and upon so many other existences as man, who has profoundly changed the living face of the earth."

We are to interpret cautiously similar human phenomena in different parts of the world. We cannot here follow the evolutionary axiom that if a species of trilobite is found in England and in New York, there has been one point of origin and a migration. The same things appear in many places, either through the unity of the human spirit or the likeness of environments, or from both causes. This is stated by Fewkes, "Identity in the working of the human mind is recognized by all anthropologists, and the tendency to ascribe cultural identities . . . . to contact or migration is much less prevalent now than formerly.[1] In like manner Boas shows that some ideas are so general that they could not have been diffused historically through migration and contact, but must have arisen independently in different places.[2]

Tylor is no less emphatic—"Researches undertaken all over the globe have shown the necessity of abandoning the old theory that a similarity of customs and superstitions, of arts and crafts, justifies the assumption of a remote relationship if not an identity of origin between races . . . . there has been an inherent tendency in man, allowing for difference of climate and natural surroundings, to develop culture by the same stages and in the same way." Citing the pyramid building of Aztec and Egyptian, "Each race developed the idea of the pyramid tomb through that psychological similarity which is as much a characteristic of the species man as is his physique."[3]

We leave this topic with the single suggestion that in the psychic field a useful and difficult piece of research is open to the student of comparative religions, who is at the same time interested in anthropogeographic problems and has the needed geographic training. How far the essential content of religious aspiration and thought, as well as the ritual of worship, has been influenced by environment, has, I think, never been shown in any

[1] "Climate and Cult," *8th Inter. Geogr. Cong.*, 670.

[2] *The Mind of Primitive Man*, 151–64.

[3] *Ency. Brit.*, II, 119, art. "Anthropology."

full synthetic way. It is a task of no common difficulty, not to be lightly undertaken, but worth the doing.

Another field of effects, much more accessible to the pure geographer, is the distribution of population studied in the causal way. Enough practice in statistical method for this inquiry can be readily acquired, and the results should be most fruitful. Jefferson's recent papers have been suggestive in this field of research, which involves in intimate combinations, physical, economic, racial, and social conditions. Akin to this study is the classification of towns and cities, developing the principles of origin, growth, and differentiation, as in a recent valuable paper of Chisholm. The city as a geographic organism may be freely taken as an inexhaustible theme.

Another great sphere lies in regional studies, such as states, physiographic units, and countries. The available number of such studies of American regions, maturely developed, may perhaps be counted on the fingers of one's hands. The aim should not be alone directed upon the more obvious matters of route and industry, but also upon deep and underlying principles. What rich and alluring subjects for the intensive student would the state of Pennsylvania offer; of Kentucky, Minnesota, or California! Who will develop for us our Coastal Plain or Piedmont, treating townsites, roads, soils, crops, industries, racial composition, and social status? Who will do a like work for the great Appalachian Valley, that magnificent and little understood unit of our East—its trails and roads, its agriculture, towns, migrations, and historical significance in colonial and current life? There is room for more such studies as those of Whitbeck upon glacial and non-glacial Wisconsin and of von Engeln on the effects of glaciation upon agriculture.[1] The latter indeed is not regional except as it naturally deals largely with principles as illustrated in our own country.

Will Mr. Mackinder, or someone else, take up Great Britain, omitting the purely descriptive, as he could not in *Britain and the British Seas* properly do, and discuss more fully questions of geographic influence as regards agricultural distribution, the localization of industries, the distribution of population in general, and the effect of various factors, such as insularity, climate, and world-position in the development of British character, British political unity, and British social conditions?

Or in the United States, there are racial compositions, new physical environments, offering new social and economic conditions to population groups as seen in comparison with conditions in the parent lands of Europe. Finally there are innumerable beckoning fields of study, of a small and local sort, out of whose diligent study general principles will rise and become established.

Our goal is broad generalization. But the formulation of general laws is difficult, and the results insecure until we have a body of concrete

[1] von Engeln, O. D.: "Effects of Continental Glaciation on Agriculture," *Bull. Amer. Geogr. Soc.*, XLVI, 241–64, 336–55.

and detailed observations. Quoting Brunhes, "We must then make up our minds to put aside generalities and vague analogies between nature and man. We must make it our business to search for facts of interaction."[1] From Boas also, "It goes without saying that haphazard application of unproven though possible theories will not serve as proof of the effectiveness of selection or environment in modifying types."[2]

Detailed investigation of single problems, in small and seemingly unimportant fields, must for a long time prepare the way for the formulation of richer and more fundamental conclusions and general principles than we have yet been able to achieve. We should not wait for someone to state or demonstrate these laws. This is yet, even for a genius, impossible. We must contribute in a partial, microscopic, sometimes unconscious way to the emergence of such laws.

Professor Adams, speaking of the available and most useful tasks of the historian, has a word which is equally good for us: "To furnish materials, to do preliminary work, is to make a better contribution to the final science than to yield to the allurements of speculation, to endeavor to discover in the present state of our knowledge the forces that control society, or to formulate the laws of their action."[3]

Not only is this a model principle, but it emphasizes the value of our goal, for the real philosophy of history will not be written until geographic factors have had broader and deeper recognition. Here I do not speak as a geographic enthusiast, nor in denial of the supremacy of the human spirit.

Such then is the mode of advance of our science—the old story of interest, hypothesis, test, correction, publication, criticism, revision; progress by error, by half-truth, by zigzag, spiral, and apparent retrograde; by aero-flight, by patient tunneling; some at the salients of progress, and some in the ranks of humble endeavor, the goal in front of all.

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[1] *Scot. Geogr. Mag.*, XXIX, 311.

[2] *The Mind of Primitive Man*, 51.

[3] *Amer. Hist. Rev.*, XIV, 236.

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THE BARRIER BOUNDARY OF THE MEDITERRANEAN BASIN AND ITS NORTHERN BREACHES AS FACTORS IN HISTORY

ELLEN CHURCHILL SEMPLE

CONTENTS

Introduction.—The Mediterranean occupies the subsidence areas in the broad belt of young, folded mountains which cross Southern Europe and the neighboring parts of Africa and Asia. Moreover, it lies on the northern margin of the trade-wind tract. These two features of its geographical location are of immense import. They have given to the Mediterranean Basin the isolating boundaries of mountains and deserts. They have made it in a peculiar sense an inclosed sea. It is inclosed, not only by the land, but by barrier forms of the land. Rarely are the barriers single, moreover. Range succeeds range to a snow-capped climax of the land: beyond mountain system or precipitous escarpment lies semi-arid waste, far-stretching desert, or rugged plateau.

These barrier boundaries long exercised a dominant influence upon Mediterranean history. For ages they confined that history within the narrow limits of the basin, except where a few natural openings offered pathways to regions of contrasted climate and production beyond. These breaches in the barrier were varied in their geographical character—a river road like the Nile across the desert, a strait like Gibraltar, an isthmus like Suez, a long intermontane trough like the Rhone Valley, or a saddle in the encircling mountains like the Peartree Pass and the low Karst Plateau. But all have focused upon themselves the historical events of wide areas. They have crowded into their narrow channels streams of trade, migration, colonization, and conquest; they have drawn these from remote sources and directed them to equally remote destinations. They have played this rôle of the guiding hand of Providence from the dawn of history to the World War of 1915.

The Mediterranean is inclosed on the north by a mountain rampart, measuring 2,330 miles in a straight line from the folded ranges behind Gibraltar to the massive Taurus System, where it looms above the Bay of Alexandretta. The huge oblong of the Anatolian Plateau, lying at an

average elevation of 3,000 to 4,000 feet (1,000 to 1,200 meters), bordered north and south by yet higher ranges rising abruptly from the sea, and edged by a rugged, inhospitable coast, lends to the Asia Minor Peninsula the character of a triple barrier confining the Levantine Basin of the Mediterranean on the north for a distance of 560 miles (900 kilometers). Its rigid billows of land, mounting higher and higher from west to east, merge into other highlands extending far into Asia. Any attempt, therefore, to round them on the east involves a toilsome journey over the ranges of Armenia, whose valley floors to be traversed lie nearly 6,000 feet (1,800 meters) above sea-level.

The Bosporus-Hellespont Breach.—On the west, this barrier peninsula sinks beneath the Ægean Sea; but its folded ranges, lifting their peaks above the waves as rocky islands, soon emerge again in the broad, corrugated highlands of the Balkan Peninsula. The blunt northwest corner of Asia Minor dips so slightly that the Bosporus and Hellespont make only a wet scratch across its surface. But that scratch is enough. It forms a clear breach in the inclosing mountain wall. Through it the Mediterranean penetrates into the Euxine Basin, but only to face other mountain obstructions encircling this great marine alcove on all but its northwest coast. The extensive subsidence between the lower Danube plain and the Crimea breaks the continuity of the folded barrier between the Balkans and the Caucasus System. The Caucasus, also, is nipped in two by the Kertch Strait, which severs the Yaila Mountains of the Crimea from the parent range, and admits the Euxine waters into the Sea of Azof. This local depression is a companion piece to the Gulf of Odessa. Only in these two inlets of shallow water does the Mediterranean penetrate beyond its normal mountain boundaries into the low, accessible plains of Eastern Europe.

Where the north wall opens its gates at the Bosporus and Hellespont, the Mediterranean reached out and drew these coastal plains of Russia into its field of history from the seventh century before Christ till the control of the Straits passed to the intruding Turks in 1453. The elements of this history were in general peaceful: commerce and colonization. Greek trading-stations and colonies at an early date began to line the Pontic shores,[1] and to send out lumber from the well-forested Caucasus, summer wheat from the Crimean plains, hides from steppe pastures, and fish from the tunny spawning-grounds.[2] Ancient Athens, poor in plowland, came to depend chiefly upon Pontic wheat to supply her market,[3] and the Scythian tribes of the Dnieper grassland came equally to depend upon Greek wine as the luxury of their meager fare. These are the chief

[1] Bury, J. B.: *History of Greece* (New York, 1909), 90–93.

[2] Strabo xi. 2, 4.

[3] Herodotus iv. 17; vii. 147. Demosthenes *De Corona* par. 73, 87. Wiskermann, H.: *Die Antike Landwirtschaft Preisschrift* (Leipzig, 1859), 14–20. Xenophon *Hellenes* v. 4. 61. Diodorus Siculus xv. 34. Bury, J. B.: *op. cit.*, 196, 379, 615, 616. Curtius, Ernst: *History of Greece* (tr. by A. W. Ward, New York, 1899), V, Book VII, 137.

exchanges today between the two localities. With every threat of interruption to communication through the Bosporus and Hellespont the price of wheat went up in Attica and Miletus, till finally Athens drew all the coastal fringe of Pontic cities and the Straits themselves into her maritime empire, and guaranteed the security of her grain trade by an unrivaled navy.[1]

By reason of this marine breach in the mountain barrier the Greeks were able to weave a border of Hellenic blood and culture upon those northern Euxine shores. Owing to the successive streams of nomad hordes from Western Asia which flooded the adjoining plains, however, Mediterranean civilization left there no permanent impress. Nevertheless, Russian traders and marauders from northern Slav principalities like Kiev, Smolensk, and commercial Novgorod, took the Dnieper River route to the Black Sea and Constantinople in the ninth and tenth centuries, and carried away the elements of Byzantine art and religion to the untutored north.

The Balkan Barriers and the Morava-Vardar Furrow.—West of the Bosporus and Hellespont the border barriers of the Mediterranean reappear, faintly at first, as the worn-down hill country of eastern Thrace. This affords an easy land road through the Maritza Valley between the Ægean and the Black Sea, and thus reinforces the marine communication through the near-by straits. The Thracian hills, however, soon rise and merge into the broad, compound barrier formed by the steep Balkan folds and the ancient crystalline mass of the Thraco-Macedonian Highlands. This old dissected mountain region, rising to heights of 9,000 feet or more in the Rhodope and Perim ranges, but sinking elsewhere to broad, undulating uplands and deep river valleys, serves to cement the young Balkan System to the multiple ranges of the Dinaric Alps. These run north and south through the western part of the Peninsula, from the head of the Adriatic to the rocky headlands of the Peloponnesus, in a forbidding succession of bold limestone ridges, which rise to jagged crests 6,500 feet (2,000 meters) above the sea. Communication between the Adriatic coast and the interior is excessively difficult. No thoroughfare is offered by the rivers Narenta and Drin, which break through the ranges in wild, impassable gorges. Travel across the country is a succession of ups and downs over gray, stony ridges and gray, barren valleys, for rarely does a saddle nick the high sky-line of the chains. Width, height, and lack of passes make the Dinaric System maintain in a pre-eminent degree the barrier nature of mountains.[2]

In all the 700-mile stretch of mountains between the Maritza Valley and the Gulf of Trieste there is no real breach, but only a few passes which are approached by long, often devious, routes across the highlands. The Morava and Vardar rivers, the one flowing north and the other south

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[1] Bury, J. B.: *op. cit.*, 365, 380–81.

[2] Based upon personal observation during a motor trip through Dalmatia, Bosnia, Herzegovina, and Montenegro in 1912.

from a low watershed (460 meters or 1,508 feet) in the heart of the Peninsula, together cut a valley furrow of gentle slopes across the mountains from the Danube near Belgrade to the northwest corner of the Ægean Sea. This furrow has from ancient times determined the north-and-south line of communication. The land route which it opens is easy but long, because it crosses a mountain mass over 300 miles wide. Moreover, travel on it is not assisted by river transportation. The Vardar, choked by sand in its passage across its swampy, deltaic plain to the Gulf of Salonica, and broken by rapids in its upper course, affords no water-way to the interior, while the Morava is navigable for only seventy miles from the Danube.[1]

The mountains about the head of the Vardar, inhabited by robber tribes from remote times, served to discourage Macedonia's expansion northward, even under Philip and Alexander the Great. Roman dominion did not overstep this barrier till 29 B.C., or a hundred and fifteen years after the conquest of Macedonia, when the Morava Valley, under the title of Upper Moesia, was embodied in the Empire. Even then the mountain watershed remained the provincial boundary, and was never crossed by a Roman road between the two valleys.

The great Roman highway of the Peninsula ran between the capital at Constantinople and the middle Danubian frontier—between the military center and the exposed border. It left the Morava Valley at Naissus (modern Nish) and followed a diagonal furrow across the high valleys between the Balkan and Anti-Balkan mountains through Serdica (Sofia), and then by the Trajan Pass (843 meters, or 2,765 feet) reached the upper Maritza Valley. Thence it led past Philippopolis and Adrianople to Constantinople. This route took a long and devious course to avoid the great highland mass of the Peninsula, and thereby became the historic highway from Central Europe to the Byzantine bridge and Asia Minor; it was essentially a land route from west to east, rather than a transit route across the mountains from north to south.

This rôle fell to the Morava-Vardar groove, and was a later development so far as historical record goes; but doubtless it played its part in the prehistoric drift of the Greek peoples from the northwest southward into Macedonia, Thessaly, and Hellas. This was the route traversed by the Ostrogoths in 473 A.D. in their invasion of Northern Greece.[2] It was the line of expansion of the Servian kingdom under the great Stephan Dusan (1336 56), whose inland domain needed an outlet on the Ægean;[3] and also the line of expansion with the same objective in the Gulf of Salonica, that was the aim of Servia in the Balkan War of 1912.

[1] Hogarth, D. G.: *The Nearer East* (London, 1905), 23, 24, 238.

[2] Hodgkin, Thomas: *Italy and Her Invaders* (Oxford, 1880), III, Book IV, note, p. 31, and map, p. 32.

[3] Miller, William: *The Balkans* (New York, 1907), 273.

Servia's location in the Morava Basin has made it custodian of these main routes south and east across the Balkan Peninsula. It blocks the path between east and west. For this reason the Turkish sultans of the fifteenth century saw that they must first occupy Servia, if they were to realize their purpose of conquering the rich fields of Hungary; and Hungary rushed to the support of Servia when the Turkish onslaught came, in order to guard the avenue leading to its own frontier. The Turks secured the control of Servia. They found its thoroughfare so necessary to them in their long wars with Hungary, that they kept a tighter grip upon Servia than upon Moldavia and Wallachia, and immediately upon its conquest in 1459 made it an integral part of their empire.[1]

From the early eighteenth century, when the Turks began their slow recessional in the Balkan Peninsula and the Austrian power its advance, the country holding the Morava highway was again the bone of contention. Between 1718 and 1739 Austria drove a wedge of occupation up the Morava Basin nearly to Nish. From the time of Emperor Joseph II (d. 1790) the domination of Servia has been a fundamental principle of Austrian statesmanship. The object has been twofold: to guard this open highway which gives access to the middle Danube from two directions; and to gain for the vast inland empire of Austro-Hungary an outlet to the Ægean and to the Bosporus, the sea breach in the mountain barrier which commands both the Black Sea trade and the land route through Asia Minor to the east.

Russia, also, since it secured its first Black Sea littoral in 1783, has made the Bosporus the objective of its expansion. It needs an outlet to the Mediterranean that cannot be jeopardized. During the closure of the Dardanelles against Italian aggression in the spring of 1912, Greek, Norwegian, and British grain ships were penned up in the harbor of Odessa, while European cities clamored for Russian wheat. More ominous for the fate of Russia in the present conflict is the exclusion of munitions from the Black Sea ports, and her inability to market the wheat which would re-establish her national credit. Her present necessity furnishes the strongest argument for final perseverance in her aim.

Passes of the Julian Alps and the Karst.—Austria's need for a southern outlet is not so urgent. She commands another breach in the barrier boundary of the Mediterranean. Near her Italian frontier at the head of the Adriatic, the broad and corrugated highlands bordering the western side of the Balkan Peninsula contract and dip as they merge into the Karst Plateau and the Julian Alps. Farther north again towers the mighty system of the Alps, rising range beyond range, up to the high, white levels of eternal snow. The Julian Alps are a slender southeastern offshoot of the main system. They attain in the north an altitude of 9,394 feet (2,864 meters) in the three-cornered peak of Terglon, but from this they shelve off southward into a rugged limestone platform of low altitude.

[1] Miller, William: *The Balkans*, 293.

Presenting toward the west a steep and forbidding escarpment, crossed by narrow ridges, pock-marked by numerous funnel-shaped cavities, and guiltless of visible drainage streams, this Karst Plateau extends along the base of the Istrian Peninsula as far as the Gulf of Fiume and the eastward-flowing Kulpa River. It merges beyond into the high, folded ranges of the Great Capella Mountains, which effectively cut off their hinterland from the sea.

Northeast of the Adriatic, therefore, for a stretch of 46 miles (75 kilometers), the mountain barrier of the Mediterranean Basin is partially breached. At one point it narrows to the width of 30 miles (50 kilometers) between the low Venetian plains and the deep re-entrant valley of erosion cut back into the highland mass by the upper Save River and its headstreams. Moreover, at this narrowest point the barrier sinks to the level of 2,897 feet in a limestone plateau known to the ancients as the Mons Ocra, and to moderns as the Peartree Range. Two rivers, the Frigidus or Wipbach on the western slope, and the Laibach on the eastern, issue from limestone caverns, after the manner of streams in the Karst country, and carve out paths down the opposite sides from the low plateau above to the plains below. Here, therefore, the Alpine barrier *et largius patentem et planissimum habet ingressum*, says the historian Paulus (720–800 A.D.), who from his boyhood had known this broad and easy entrance, and had seen a barbarian horde burst through it as through an open door.[1]

There were other routes across the mountain saddle, as we shall see, but this was the best, and from very ancient times it became a well-trodden path. Here concentrated the traffic of a far-reaching hinterland. The geographical reasons are plain enough. The Peartree Pass afforded the shortest and lowest transit route to the interior in the whole 1,300-mile stretch of mountains between the Bosporus and the Rhone Valley breach. It lay between two natural thoroughfares, the level plains of Northern Italy and the wide plain of the Danube, which cannot be separated geographically or historically from the nomad-breeding steppes of Southern Russia. The Drave and Save rivers, tributaries of the Danube, drain the longitudinal valleys of the eastern Alps and open avenues of easy grade far up the eastern slope of the dividing range. Moreover, this dip in the mountain wall was located between the head of the Adriatic, an old sea-lane of maritime enterprise, and the head of navigation on the Laibach-Save-Danube System. For the little Laibach can carry a barge soon after it issues from its cavern. It springs full grown from the mountain's womb, such strength has it gathered in its underground life, fed by a whole arterial system of hidden rivers.

The historical importance of passes increases with their facility of transit; with their command of valley thoroughfares and water approaches, either navigable rivers or seas; and with the contrast between the regions of productions, both in point of climate and of industrial development,

[1] Quoted in T. Hodgkin, *op. cit.*, V, Book VI, note, p. 160.

which such passes serve to unite and whose trade they forward.[1] All four of these advantages were possessed by the Peartree Pass in a high degree. Its claim to the first two has been indicated. Through all ancient and mediaeval times it connected the civilized and industrial Mediterranean lands with a vast hinterland of barbarism, with shifting tribes of nomadic herdsmen and semi-nomadic agriculturalists. It facilitated the exchange of artistic manufactured products in bronze, pottery, linen and woolen fabric for the crudest raw materials from forest, pasture, and mine.

The contrast in climate is almost as marked. The Julian Alps and Karst Plateau are a heat divide. On their slopes the warm, temperate climate of the Mediterranean Basin meets the cold temperate climate of Central Europe. The January isotherm of 0 degree C. (32 degrees F.), which marks the dividing line, nowhere else approaches so near to the Mediterranean proper as here. It runs through Bremen, Munich, along the watershed of the Karst, then turns southeast into the heart of the Balkan Peninsula. A similar contrast of winter temperatures in an equally short space appears on the opposite side of the Caucasus windshield, along the Black Sea littoral. The Peartree Pass, which is located approximately on the forty-sixth parallel of latitude, looks down upon the olive trees and rice fields of the warm Venetian plains. Here Italy revealed her fatal gift of beauty to the barbarian hordes who pushed up the Danube highroad to the half-open gate of the Hesperian Garden.

The ancient Mons Ocra route left the Adriatic at Aquileia, a Roman river port located four miles up the navigable Aquilo, accessible to the sea but somewhat protected from the chronic piracy of the Adriatic. Turning eastward, the road crossed the Sontius (modern Isonzo) and led up the fertile valley of the Frigidus (Wipbach) to the summit of the Mons Ocra plateau. There the easiest path across must have run past a wild pear tree, whose white blossoms made a conspicuous landmark against the green of the surrounding forest when spring reopened traffic on the road. At any rate, the Roman roadmakers called the station at the summit Ad Pirum. This name survives in the Peartree Pass and the Birnbaumer Wald, the German name of the old Mons Ocra plateau. From the summit (2,897 feet) the road dropped down to Nauportus (modern Ober-Laibach, at 970 feet) on the Laibach River, where navigation began on the Save-Danube System. Strabo states that the distance between Aquileia and Nauportus was variously estimated from 350 to 500 stadia, or 40 to 57 miles.[2]

The Romans knew of another track over the Mons Ocra Range, leading up from Tergeste (Trieste) to Lacus Lugeum (Lake Zirknitz), and thence to Nauportus.[3] This route had marked disadvantages. It ascended the

[1] Semple, E. C.: *Influences of Geographic Environment* (New York, 1911), 546, 549.

[2] Strabo iv. 6. 10; vii. 5. 2. For the modern road in detail, see Kröhn, Walter: *Beiträge zur Verkehrs-geographie von Krain* (Königsberg, 1911), 61–62.

[3] Mommsen: *History of Rome* (New York, 1873), III, 215. For the modern road, see *ibid.*, 63. Canstein, P. von: *Die oestlichen Alpen* (Berlin, 1837), 235–58.

plateau by no long valley of approach like that of the Frigidus, but mounted the steep escarpment overhanging the Gulf of Trieste. Though it may have found a lower gap than the Peartree Pass, it had to traverse the plateau at its greatest width and therefore to cross the successive hill ranges that corrugate its surface. Moreover, the plateau is almost devoid of water, which everywhere seeps through the porous limestone to some impervious stratum of clay or sandstone. None remains on the surface to carve out a river valley of easy travel for the wayfarer. Therefore this route seems early to have been abandoned in favor of the Peartree Pass. Centuries later it was partially revived when Aquileia and the other ports along the low Venetian coast were silted up by the deposits of muddy Alpine torrents, and were therefore superseded by the deep mountain-rimmed harbor of Trieste. This harbor was the geographical determinant which made the modern railroad follow the plateau route and grapple with the problem of mounting its bold escarpment.

This second Mons Ocra route lacked early historical importance also because it did not debouch upon the fertile Venetian plains. It was therefore generally neglected by invading hordes from the Danube, whose objective was the rich cities of Cisalpine Gaul. The barbarians preferred as alternatives two routes to the north of the Julian Alps. These were approached by the valley highways of the upper Drave and Save rivers, and crossed the mountains by a high saddle between the Julian and Carnic Alps. The eastern starting-point for both was the ancient Santicum (modern Villach), located at an altitude of 1,665 feet, in a broad and lake-strewn basin at the head of navigation on the Drave. It had a situation similar to that of Nauportus. From this point one track led south over the Col di Tarvis and the difficult Predil Pass, called the "Thermopylae of Carinthia" (3,810 feet or 1,162 meters), to the head of the Sontius Valley (Isonzo), which opened a way down to the coast near Aquileia.[1] The Predil Pass was too difficult to attract a military road in ancient times, though it was the route of the invading Lombards in 568 A.D. A few miles to the west of it, through the Pontebba or Pontafel Pass (2,615 feet or 797 meters), ran the other route from the Col di Tarvis, which connected on the Italian slope with a headstream of the Tiliaventus River (Tagliamento). In the days of the Empire a Roman military road followed this route over the Alps, and connected Aquileia with the navigable course of the Drave,[2] but for the trader it involved a long detour from his market.

The ancient amber route from the Baltic, one of the earliest trade routes of Europe, doubtless reached the Mediterranean by all these passes, especially in its primitive stages, when it was trying all the paths to find the easiest. This is the evolutionary history of all the pioneer roads. The amber route started from the famous amber fields of the southeastern

[1] For modern road, *see* Baedeker: *The Eastern Alps* (Leipzig, 1888), 441–42. Krebs, Norbert: *Länderkunde der oesterreichischen Alpen* (Stuttgart, 1913), 401, 409.

[2] Shepherd, W. R.: *Historical Atlas* (New York, 1911), map, p. 27.

Baltic, especially those of the Samland, and led up the Vistula or Oder River to the Moravian Gate, a broad geological gap between the Carpathian and Sudetes mountains, which was once a passage of the Eocene Sea. The route led thence down the March River to the Danube, thence across the spreading spurs of the eastern Alps to the Save Valley, the shrunken barrier of the Julian Alps, and the Mons Ocra Pass.[1] According to Pliny, amber was brought by the Germans to Pannonia (Carinthia and Carniola), and purchased from them by the Veneti living on the north Adriatic coast. He mentions the amber necklaces worn by the women of this region, not only as an ornament, but as a protection against sore throat.[2]

So regularly did the Baltic amber emerge here upon the horizon of Mediterranean commerce that the myth of Phaeton's sisters, transformed into poplar trees and weeping tears that turned into amber, associated the precious commodity with the mouth of the Po River,[3] showing that the trade must have reached back into exceedingly ancient times. Herodotus reports its supposed origin at the mouth of a stream flowing into the northern sea,[4] the Eridanus, a name which later came to be identified with the Po. He also clearly indicates a route of communication from the far northern land of the Hyperboreans, which emerged at the head of the Adriatic and passed down this sea to Epirus.[5] The offerings to Apollo's shrine at Delos which he describes as taking this long journey were probably forwarded down the Adriatic by the trading ships of Corcyra and Epidamnus, which nearly three centuries before had been colonized by Corinth for the purpose of exploiting the commerce of this basin. The inland trade from the head of the Adriatic was appropriated at an early date by the Etruscans, and pushed with an assiduity which suggests that besides amber, other valuable northern products, like gold and tin from mines in the Archean rocks of the Bohemian massif, may have reached the Mediterranean by the Peartree route.

According to a tradition reported by Pliny, the Argonauts sailed up the Danube and Save to the head of navigation on the Laibach, and there built a settlement which they called Nauportus, because from there they carried their ship "Argo" across the mountains on men's shoulders to the Adriatic.[6] The feat is not impossible, in view of the elevation of Nauportus (970 feet), only 2,000 feet below the pass; the probable presence here of stalwart mountain packers, such as are found in all pass regions of the world; the desire of such poverty-stricken mountain tribes to make money by this service and by levying tolls on the traffic over their mountain trails; and especially in view of the small vessels of this legendary period.

[1] Mommsen: *op. cit.*, I, Book I, 177, 196, 266.

[2] Pliny *Historia Naturalis* xxxvi. 2. 11.

[3] Diodorus Siculus v. 22 (Paris, 1855). Pliny *op. cit.* iii. 30.

[4] Herodotus iii. 15.

[5] Herodotus iv. 33.

[6] Pliny *op. cit.* iii. 22.

The Homeric Greeks had boats of only twenty oars. The large pentecontor of fifty oars hardly came into use before the eighth century B.C., and it appears in the later Homeric poems as a masterpiece of sea-craft.[1] When one considers that the Bolivian Indian carries 150 pounds of rubber over the Andean watershed,[2] and that the tea-packer of Western China shoulders a burden of 300 pounds for the arduous ascent of the Central Asiatic Plateau,[3] a twenty-oared boat carried on "the shoulders of men" across the Peartree Pass seems an easy undertaking for a group of mountain porters. It may be the first historical mention of the watershed "portage" or "carry," which is a regular feature of primitive inland navigation the world over. The portage is a commonplace of the Indian canoe routes in the Western Hemisphere, in the pioneer exploration and fur trade of Canada, the United States, Russia, and Siberia. Isthmian portages were familiar to the Greeks from very ancient times on the Isthmus of Corinth, in Eastern Crete, and probably on the narrow Dalmatian islands.[4]

In the case of Pliny's story, what probably happened was that some enterprising Greek inland traders may have found their way up the Danube to the Laibach, made their "carry" to the Isonzo River and Adriatic, and after long years their bold exploit was embodied into the tradition of the Argonautic expedition. Such was the process of accretion by which the *Odyssey* grew. The use of this portage path for boats may have given rise to the persistent impression among the ancients that there was river connection between the head of the Adriatic and the Danube.[5]

Strabo emphasizes the value of the Mons Ocra route for forwarding military supplies to the Roman armies engaged in war with the Dacians on the lower Danube. But this was only part of the traffic. Merchandise in large quantities was carried by wagon from Aquileia to Nauportus, and thence by boat to Segestica (Sisek), an important distributing point at the confluence of the Save and Kulpa rivers. There was an active trade between Italy and the barbarians of the upper Danube. The exchanges were the usual ones between two regions of different climates and contrasted economic development. The barbarians sent over the pass cattle, hides, slaves captured in their incessant border wars, gold from the Alpine mines, resin, pitch, and other forest products. They received in return the oil and wine of Italy, fine fabrics of Mediterranean make, glass, and pottery.[6] The flourishing emporium for all this trade was the fortified town of Aquileia, at the head of the Adriatic.

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[1] Bury, J. B.: *op. cit.*, 109.

[2] Church, Col. George E.: "The Acre Territory and the Caoutchouic Region of South-Western Amazonia," *Geogr. Journ.*, XXIII, 596–613.

[3] Huc, M.: *Journey through the Chinese Empire* (New York, 1871), 39–40.

[4] Rudolphi, Dr. H.: "Trageplaetze und Schleppwege oder Portagen," *Deutsche Rundschau für Geographie*, XXXIV, 66.

[5] Pliny *op. cit.* iii. 22. Apolonius Rh. iv. 283. Strabo iv. 4. 9. Aristotle *Historia Animalia* viii. 13. Supported also by Hipparchus and Theopompus.

[6] Strabo iv. 6. 9. 12; v. 1. 8; vii. 5. 2.

The location of Aquileia was not altogether a fortunate one, however. Here on the eastern land frontier of Cisalpine Gaul lay the weak spot in the Alpine frontier of Italy. Here, therefore, at the eastern extremity of the big province lay the local capital, Aquileia, in a position of opportunity, but also of danger. The city was founded in 181 B.C., soon after the Roman conquest of the region, as a fortress against intrusive Celtic peoples, who were already beginning to threaten this vulnerable frontier. Their first detachment came in 186 B.C., quietly enough, though they could muster 12,000 fighting men, Livy tells us.[1] They were bent upon peaceable settlement, so they arrived with "all their property which they had brought with them or driven before them." The road which they took across the forested mountains was previously unknown to the Romans, but it lay at the very head of the Adriatic.[2] They emerged from this unknown pass upon the Venetian plain, and set to work building their villages in the vicinity of the later Aquileia. But they were ordered out by the Roman proconsul, and had to obey.

The Senate, finding the Alps in this region not the "almost impassable barrier" that they had supposed them to be, established Aquileia as a Latin colony to protect the border. The new settlement was a peculiarly remote outpost of the military frontier. The nearest Roman colonies, which marked the line of continuous settlement and of assured civil government in the young province of Cisalpine Gaul, were Bononia, Mutina, Parma, and Placentia. All were located at the northern foot of the Apennines along the new Via Æmilia, and all had been built within the four previous decades. Then only two years after the founding of Mutina, Aquileia was established over a hundred and fifty miles away, an ethnic island, dropped down in a sea of Veneti allies. A sudden protrusion of the frontier like this means that the expansion is necessitated by danger or suggested by opportunity. The situation evidently required peculiar inducements, for the 3,000 militia colonists who were assigned to Aquileia received extraordinary allotments of land, 50 *jugera*, or 32 acres, to every foot soldier and 150 *jugera*, or 96 acres, to every horseman.[3] This was eight or ten times the usual allowance.

The border cantonment was established none too soon. In 179 B.C. came another Gallic band of 3,000, pushing across the Alps and asking for land. More serious seemed the threat of Philip of Macedon to lead a horde of his mountain barbarians into Italy by this convenient northeast frontier. So the Romans, preparing for all emergencies, conquered the Peninsula of Istria in 177 B.C. to extend their scientific mountain boundary, to secure their sea communication with Aquileia, and to suppress Illyrian piracy in the upper Adriatic.[4] The appearance of the migrating Cimbri

[1] Livy *Historia* xxxix. 22. 45.

[2] Mommsen: *op. cit.*, II, 232–33.

[3] Livy *op. cit.* xxxix. 34.

[4] Heitland, W. E.: *The Roman Republic* (Cambridge, 1909), II, 141–42.

at the approaches to the eastern Alps in 113 B.C. summoned the Roman army to the heights near Aquileia in order to protect the passes, but the barbarians withdrew, only to find their way by the upper Danube and the Burgundian Gate to the Rhone Valley approach to the Mediterranean.[1]

The policy of the Romans on this northeast frontier was quiescent and defensive. The Peartree Pass was the back door of Italy; the Danube Valley, on which it opened, was a back street of the continent. Italy and the Tiber Valley fronted on the western Mediterranean. This was the result of the eastward curve of the Apennines, which threw the large populous plains and valleys on the sunset side of the peninsula, and centered their interests on the western sea. Therefore Rome's inland expansion first sought the Rhone Valley breach to the north, though the Peartree Pass route had been known to the Etruscans, the most ancient commercial expansionists of Italy. Genuine expansion beyond this mountain boundary began in the time of Augustus with an effort to police this frontier, a common first forward step. Depredations of the mountain tribes behind Istria upon Tergeste and Aquileia in 35 B.C. necessitated the conquest of all the highland hinterland.[2] In 10 B.C., the process had to be repeated in order to teach the predatory tribes of the Julian Alps respect for property, and especially to open up the Peartree Pass route for merchandise and armies bound for the new Danubian provinces. Ere long a Roman road crossed the Mons Ocra to the colony of Æmona, where Laibach now stands. Siscia on the lower Save became an important garrison town.

During the *Voelkerwanderung* the danger of invasion was always imminent. The towns of Venetia were the first to glut the barbarians' greed for massacre and rapine, because the Danube avenue, immemorial highway for the packs of human wolves from the Russian and Asiatic steppes, led straight to the mountain door of the Venetian plains. The first historic invader to cross the Peartree Pass and spread his tents upon the banks of the Sontius was the emperor Theodosius the Great. In 388 A.D. and again in 394 A.D. he advanced from Constantinople up the Danube to interfere in the turbulent affairs of decadent Rome. Siscia on the lower Save, Æmona, and Aquileia saw his formidable army, and the battle of the Frigidus River below the Peartree Pass determined the conquest of the Roman Empire of the West by the Roman Empire of the East.[3]

The Visigoths, who participated in the campaign of Theodosius, learned how easy was the road to Italy and how weak were the defenders. Under their leader Alaric in 402 to 403 they invaded Italy. Taking the route through Pannonia to the Julian Alps, they pushed aside the guardians of the pass and descended rapidly to the siege of ill-fated Aquileia. Alaric overwhelmed Venetia and the neighboring Peninsula of Istria; but, defeated by the Roman general Stilicho at Verona and Pollentia, he

[1] Mommsen: *op. cit.*, III, 215–16, 221.

[2] Bury, J. B.: *History of the Roman Empire* (New York, 1909), 95–98.

[3] Hodgkin, T.: *op. cit.*, I, Book I, 159–69.

retired from Northern Italy, checked but not broken. The Romans found him an enemy to be conciliated, for they appointed him *magister militae* or commander of the Roman armies throughout Illyricum, which included Pannonia and Dalmatia. Thus they utilized his barbarian forces as a border defense on a weak and exposed frontier, as nations have been wont to employ their nomadic or semi-nomadic neighbors in all times and all parts of the earth.[1] Alaric now held a strategic position. He fixed his camp at Æmona, where the Peartree Pass road reached the Save River. From that base he demanded the pay due himself and his men for their services, and when he failed to get it from the disorganized government, he again invaded Italy in 408. Once more the Peartree Pass led him over to the siege of Aquileia and the other Venetian towns,[2] and the ancient Etruscan route from the mouth of the Po over the Apennines guided his forces to Rome. After the siege and sack of the capital, Alaric demanded territory for his Visigoths in Venetia, Dalmatia, Pannonia, and Noricum, and the office of *magister militae* for himself, so that he might again command the important line of communication between Italy and the Danube.[3] His sudden death put an end to this demand, but his victorious followers moved westward out of Italy into Southern Gaul, where they received an allotment of land.

The departure of the Visigoths from the territory of Illyricum had left a vacant border. This meant that the gate of the Julian Alps was thrown open as if in invitation to other rude visitants. East of the previous Visigothic settlements in Pannonia lay the great empire of the Huns, who for a century had been pushing up the Danube Valley. Checked by the German tribes of Northern Gaul in his efforts to conquer that region, Attila, king of the Huns, turned toward the weaker prey of Italy. In 452 he led his savage hordes by the undefended road of the Julian Alps straight to the walls of Aquileia. Having sacked and destroyed that city, he laid waste the Venetian plains,[4] whose refugees sought an asylum in the coastal lagoons and marshy islands to the west, and there gave rise to the terror-haunted beginnings of Venice. Attila withdrew to his home beyond the Danube, but the destruction which he wrought in the Po Valley had not been repaired before the Ostrogoths under Theodoric, in 488, moved westward from their capital, near the present city of Belgrade, up the valleys of the Save and Drave to the Julian Alps. They dropped down the valley of the Frigidus and pitched their camp by the Isonzo.[5] Here, on this chronic battlefield, they defeated the Roman army of the emperor Odovacar.

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[1] Semple, E. C.: *op. cit.*, 233–35.

[2] Hodgkin, T.: *op. cit.*, I, Book I, 250–51, 257–58, 280–82, 317.

[3] Gibbon: *Decline and Fall of the Roman Empire* (London, 1908), III, 250–57, 275–76, 287, 312–13.

[4] Hodgkin, T.: *op. cit.*, II, Book II, 164–70.

[5] *Ibid.*, III, Book IV, 202–11.

Eighty years elapsed before the teeming hive of the Danube plain threw out another swarm. The next to mount the Julian barrier were the Lombards, in 568. In the course of long migrations they had drifted from the mouth of the Elbe River southward to Pannonia, and after a temporary halt they moved up the Save Valley through Æmona to the Peartree Pass and Venice.[1] This seems their probable route, though according to one authority they reached the Venetian plains by the higher and more difficult Predil Pass from the upper Drave Valley to the head of the Isonzo.[2] It is quite possible that the large and motley horde, incumbered by wagons, their families, flocks, and herds, found it necessary to use both routes in order to make a sudden descent upon the Venetian plains. From this base they ravaged all Italy, and eventually gave their name to the plains west of the Adige and north of the Po.

The easy approach up the long inland slope of the Julian Alps, the march across the low passes, and the swift descent down the steep seaward slope of the ranges was a historical event that must easily repeat itself. This was apparent to the new Lombard conqueror. Hence he opened a new chapter in the history of Northeastern Italy. He erected all the Venetian plain between the Mincio River, the Po, the Carnic Alps on the north and the Julian on the east, into the border Duchy of Friuli, with Forum Julii as its capital. To its Duke he intrusted the hazardous and responsible task of guarding the mountain passes leading to the Danube. The Duke stipulated for the noblest, most valorous Lombard clans to form his soldiery and the finest brood mares to sustain his border cavalry.[3] Thus was established here a typical frontier principality of defense, after the order of the German *Mark*. A hundred years later its chief was called a *Markgraf;* and from this time for five hundred years, so long as the human cauldron on the Danube seethed and boiled and overflowed, there was always a *Mark* of fluctuating boundaries and varying name that rested upon the Julian Alps.

This Lombard frontier state took its name from its capital, Forum Julii (modern Cividale), originally a market built by Julius Caesar in the foothills of the Julian Alps. It was a typical pass town, located on the northeast margin of the Venetian plains where it could command the trade which the Peartree, Predil, and Pontebba passes brought over from Pannonia and Noricum. As a base for guarding these passes, the site offered better facilities than Aquileia, which never recovered from the Hun's attack and retained only ecclesiastical importance. The frontiers of the Duchy probably reached north to the summit of the Carnic Alps, east to the crest of the Julian Range and the Karst, south to the Adriatic coast, and west to the Tagliamento River. It therefore had natural or scientific boundaries on its exposed sides. On the north its Bavarian

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1 Villare, Pasquale: *Barbarian Invasions of Italy* (London, 1902), II, 279.

2 Hodgkin, T.: *op. cit.*, V, Book VI, 158–69.

3 *Ibid.*, 160–61; VI, Book VII, 38–41.

neighbors were giving evidence of aggression. Slovenians, an advance guard of the great southern Slav migration, occupied the eastern slopes of the Julian Alps. They were a small detachment of herdsmen and farmers, who in reality served as a border outpost of defense against the dreaded Avars and other intrusive peoples of Mongolian stock occupying the middle Danube plains.

The mere presence of these nomadic hordes in the near-by pasture lands was a threat. In about 610 the Avars swept across the Julian or Carnic passes from the Save and Drave. They spread desolation among the Lombard cities of the Duchy of Friuli, much as the Lombards had done a few decades before among the Roman cities of this fertile but exposed province. After the raid they retired, only to return again in 663, this time by the Peartree Pass. In the chronic battlefield of the Frigidus Valley they defeated the Duke of Friuli, ravaged the Duchy, and again withdrew.[1] The Slav neighbors on the eastern slopes of the Julian Alps were probably impoverished by the Avar raids; for a few years after (688–700) they resorted to systematic cattle-stealing—the ancestral occupation of barbarian mountaineers—crossed the border and despoiled the herds in the Friulian pastures. Punitive expeditions to stop these depredations only served to incite the warlike spirit of the Slovenians. They invaded the Duchy by the Predil Pass, and defeated the Duke's forces in the valley approach below.[2] These Slovenians, however, gradually became assimilated, through constant intercourse, to the higher civilization of the Duchy of Friuli. Their territory, which received the Slav name of Krajena or Krain, or "frontier,"[3] occupied the mountain country between the Kulpa River on the south and the Karawanken Alps hemming in the Save Valley on the north. It was conquered by the Duke of Bavaria in 772, and in 788 was embodied in the Frankish Empire by Charlemagne, who thus secured the strategic portion of the old Roman Pannonia for the defense of his wide dominion, and erected it into the *Mark* or March of Friuli.

During the ninth century, the Karling kings of Italy paid much attention to strengthening this weak frontier. They extended the March of Friuli west to the Adige River and reinforced it by the addition of the March of Istria, thus giving it command of the whole stretch of the Julian Alps and Karst highland down to the present Gulf of Fiume. Beyond the crest, on the eastern slope, they had an additional defense in the Krain, or March of Carniola, which formed a frontier state of the east Frankish Kingdom or German Empire.

During the ninth century these three Marches served as outposts against the migrant Avars. At the end of this period they faced a new enemy from the Danubian plains. These were the Magyars or Hungarians.

[1] *Ibid.*, VI, Book VII, 50–54, 286–87.

[2] *Ibid.*, 328–31.

[3] *Encyclopaedia Britannica*, art. "Carniola."

For a long time they had been moving along the broad highway of migration across Southern Europe, pressing on the rear of the Slavs and Avars, till they occupied all the present territory of Hungary except the narrow arm of land stretching through Croatia to the Adriatic. The exposed duchies of the German Empire threw out a series of defensive vassal states, endowed with unusual privileges and unusual responsibilities, as buffers and bulwarks against the enemy. It was a political process of thickening the hide of the Empire, so to speak. It was a process as natural as that of protective coloring in plants and animals, and it is one that has been developed on exposed boundaries the world over, and the ages through.[1]

These German border states established to ward off Hungarian agression were the March of Moravia, the March of Austria, the March of Carinthia, the March of Styria, and the March of Carniola. Behind the last lay the Italian March of Friuli, which was also of Teutonic origin. The *Markgraf*, or ruler of a March, had the legal status of the older counts, but he controlled a much larger territory and enjoyed far greater independence, as his dangerous frontier location demanded. He exercised justice, maintained a standing army, and had the right to call out militia from his population; but in return for this enlarged authority he assumed the grave responsibility of defending the border state.[2]

The proximity of Italy tempted the first inroads of the Hungarians. In 899 or 900 they descended from the mountain rim of Friuli, "the most harmful door left open by nature to chastise the faults of Italy," and ravaged as far west as Pavia.[3] They came again in 921, and yet again in 924 at the request of King Berengar, who was on friendly terms with the Hungarian chief, but was threatened by his rebellious Lombard vassals. These facts suggest steady intercourse, probably commercial, between the Italian cities and the barbarians, by way of the Julian Alps and the Karst passes. The desolating raids became almost annual, spreading farther and farther—to Apulia in 922, to Rome in 926, and to Capua in 937. They emerged upon the horizon of Italy somewhere in the Friulian or Venetian plains, *per ignotas vias*, the chronicler says;[4] but they had no connection with the numerous Hungarian incursions along the upper Danube Valley into Bavaria, Swabia, and Alsace. These facts seem to justify the assumption that they came by the old eastern passes, especially since the northern passes had long been guarded by the Bavarians. When the German king, Otto the Great, became overlord of Italy in 952, he transferred Friuli, now called the March of Verona, and the March of Istria to the Duke of Bavaria, who at the same time ruled over Carinthia and the March of Carniola.

[1] Semple, E. C.: *op. cit.*, 233–34.

[2] Waitz, G.: *Deutsche Verfassungsgeschichte* (Kiel, 1876), VII, 84–94.

[3] Thayer, William R.: *Short History of Venice* (New York, 1905), 32.

[4] Marquart, J.: *Osteuropäische und ostasiatische Streifzuge circa* 840–940 (Leipzig, 1903), 156–58.

Thus he effectively closed the way to Italy against the raids of the Hungarians.[1] A little later, in 976, Carinthia was erected into a duchy, ruling over the vassal Marches of Friuli, Istria, and Carniola, and served, like Bavaria twenty years before, as a sort of chief of the border police.

These frontier provinces were transferred so often and so arbitrarily by the politician emperors of the Middle Ages in payment for votes in the imperial elections that any geographical law in the combinations became obscured. However, one or two principles emerge out of the chaotic changes. The March of Carniola, because of its location across the sunny path to Italy, retained longest (till 1254 or later) the March constitution and privileges which at once facilitated and repaid the task of defending the frontier. There seems to have been a recognition of the fact that this border state on the eastern slope of the Julian Alps was only a part of a geographical whole; therefore a recurrent tendency is revealed to combine it with Istria and Friuli,[2] and thus to round out the geographical whole comprised in all the wide frontier zone of defense.

The growing Republic of Venice during the twelfth and thirteenth centuries gradually absorbed most of the coastal belt of the Istrian Peninsula. This brought a turning-point in the history of Carniola. The March acquired nearly all the territory that was left of the old March of Istria, and for the first time (*ca.* 1250) it had a small littoral of its own on the Gulf of Trieste and the Gulf of Fiume. Moreover, it extended to the lowlands of the Isonzo, though not to the river. In other words, the March of Carniola was astride of the Julian Alps and the Karst Plateau, with a foot resting on the Adriatic shore. This location gave it an entirely new significance and value. It was no longer merely a strategic border state, but a border state with a sea front, and as such it became an object to the inland states.

Carniola was momentarily acquired between 1269 and 1276 by King Ottocar of Bohemia and Moravia, who had managed to get into his own hands all the old belt of March lands stretching from the Julian Alps to the head of the Vistula and Oder rivers in the Moravian Gates. Since he had shortly before founded the city of Koenigsberg on the coast of East Prussia,[3] his long-strung possessions comprised most of the old amber route. Ottocar was forced by the emperor Rudolph of Hapsburg to renounce his recent acquisitions, all of which except Carinthia and Carniola went to found the fortunes of the House of Hapsburg. Later we find another Bohemian king endeavoring to secure for Bohemia those important territories as a passway to Italy.[4] His plans were frustrated by the growing power of Austria, which also felt a vital need of stretching its frontier to Italy and the sea, and which in 1335 acquired Carniola.

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[1] Huber, Alfons: *Geschichte Oesterreichs* (Gotha, 1885), I, 136.

[2] *Ibid.*, 218–20.

[3] Freeman, E. A.: *Historical Geography of Europe* (London, 1882), 319.

[4] Coxe, William: *History of the House of Austria* (London, 1847), II, 105–6.

This marchland of Carniola, which had originated on the eastern slope of the Julian Alps as an outpost of successive Italian powers, now faced about westward. It became Austria's exposed frontier toward expanding Venice, and gave to inland Austria its first narrow foothold upon the sea. While its eastern border never changed, thus evidencing the equilibrium between pressure and counter pressure of nations in the Danube Valley during the later Middle Ages, on the west Carniola gradually acquired the valley of the Isonzo River and the base of the Istrian Peninsula. Thus it comprised all the weak highland barrier which it served to defend. Its western frontier toward Italy constantly fluctuated; but throughout its subsequent history from 1335 till 1807 it managed to keep some strip of seaboard on the Adriatic, at Trieste or Aquileia or on the littoral between, besides a coastal *pied de terre* on the Gulf of Fiume. This it accomplished despite the century-long efforts of the Venetian Republic to exclude Austria from the Adriatic, and to get closer access to the trade routes leading over the Peartree and Pontebba passes. By these routes Venice fed her products into backward Austria. During the Middle Ages 40,000 packhorses came yearly from the north down to Istria to take back Venetian salt to the Austrian Empire.[1]

When the fall of Constantinople let loose another flood of barbarians into the flat Danube plains, Carniola again became the fighting marchland. Under the hot blast of Turkish attack Hungary shriveled up like a dead leaf. Its frontier rolled back within forty or fifty miles of the old Austrian Marches. Across this narrow buffer territory poured the Turks into Carniola, in 1463, 1472, 1473, 1493, 1521, and again in 1559.[2] Laibach saw the Mongol cavalry around its walls.[3] Once more the migrants of the Danubian plains stormed this half-open door of Italy. Once more the geographical location of Carniola made her the mountain warden of Venetian Italy until, in 1683, the Turkish advance spent itself and gave place to a century-long retreat.

During the Napoleonic Wars these lines of easy communication between Austria and Italy were the scenes of marching and counter-marching. Napoleon, in 1787, erected a new Illyrian state out of Carinthia, Carniola, Goerz, Istria, the coast of Dalmatia, and Croatia, to be "a guard set before the gates of Vienna," as he said.[4] With true geographical insight he was reviving the old March of the Julian Alps and the Karst Plateau with somewhat extended boundaries.

In his great Austrian campaign of 1797, from his base at Treviso, north of Venice, Napoleon met the same military problem, determined by

[1] Thayer, William R.: *op. cit.*, 93.

[2] Abbot: *Austria, Its Rise and Fall* (New York, 1902), 70, 71, 75, 83, 146, 147. Huber, Alfons: *op. cit.* (Gotha, 1892), IV, 13.

[3] Leger, Louis: *History of Austro-Hungary* (London, 1889), 154, 258.

[4] Seton-Watson, R. W.: *The South Slav Question, and the Hapsburg Monarchy* (London, 1911), 26.

geographic conditions, as that now facing the Italian army of invasion in 1915. His method of solution was the same. He sent Jourbert with an army by the Adige Valley into the Tyrol, and Messena by the Pontebba Pass and the Col di Tarvis into Carinthia, to intercept Austrian reinforcements coming either from Germany or from Vienna. He himself attacked the Austrian army under the archduke Charles on the Tagliamento River, drove them back across the Isonzo, took Gradisca, Monfalcone, Trieste, and Fiume, and made his temporary headquarters at Goerz, an old stronghold at the outlet of the Wipbach Valley. From there he sent Bernadotte to pursue the archduke Charles, who had retired from Goerz across the Peartree Pass upon Laibach, and to occupy Carniola. Napoleon sent another force on the trail of a second Austrian army, which was withdrawing up the Isonzo Valley to the Predil Pass in the hope of securing the Col di Tarvis and the road through Carinthia to Vienna. It was crushed, however, by Massena's army, which was waiting for it above, and the pursuing army, which Napoleon accompanied. The commander made his successive headquarters at Goerz, Caporetto, Tarvis, and Klagenfurt in Carinthia, where he reunited the three divisions of his army for the advance upon Vienna.[1]

In the Franco-Austrian War of 1809, Austrian forces under Archduke John invaded French Italy by the Pontebba–Col di Tarvis route and defeated the opposing army at Sacile, just west of the Tagliamento.[2] But subsequent reverses in Italy and discouraging news of the progress of the war in Austria forced the archduke John to retreat by Pontebba Pass and Col di Tarvis into Carinthia, which, together with Carniola, was soon after abandoned to the pursuing French. Napoleon in his congratulatory address to the army of Italy enumerated the scenes of their victories, names familiar to history, the upper Tagliamento Valley, Tarvis, Fort Malborghetto, Goerz, the Save, and the Drave.[3]

The Italian armies of King Victor Emanuel are compelled by geographic conditions to follow in the footsteps of Napoleon and his generals. One has advanced by the Adige Valley north into the Trentino or southern Tyrol; another has moved northeast across the Pontebba Pass, to sever the Trentino's communication with Vienna through the longitudinal valley of the Pusterthal and to protect the Venetian plains from a flank attack; a third army has marched east across the Isonzo, taken the border defenses at various points along the left bank of the river, and now is planning to invest the strong fortress of Goerz, while another division has occupied Monfalcone on the advance to Trieste. The rapidity of the several movements, however, as compared with those of a century ago, is much slower. It is retarded by the vastly increased difficulty of forcing

[1] Fournier, August: *Napoleon the First* (tr. from the French, New York, 1904), 97–98. Hazlitt, William: *Life of Napoleon* (London, 1830), II, 23–26.

[2] *Cambridge Modern History* (New York and London, 1906), IX, 355.

[3] Hugo, A.: *Geschichte des Kaisers Napoleon* (tr. from the French, Stuttgart, 1834), I, 415–17, 429.

mountain passes which are defended by modern fortresses, by masked artillery stations tunneled into mountain walls with only an external orifice for the cannon's mouth, by long-range guns in commanding positions, and by wire entanglements. These military equipments of defense have restored much of the pristine barrier nature of mountain boundaries which was theirs before the construction of roads and the clearing of forests. The present campaign in the Julian Alps may therefore prove these highlands to be the "almost impassable barrier" to hostile invasion which they were considered to be over two thousand years ago by the Roman Senate. Such is the power of human inventions to modify the effect of geographic conditions.

The accessible nature of the Julian Alps and the Karst Plateau under normal conditions is evidenced also by the distribution of population in these highlands, and by its ethnic elements. Nowhere else in the whole semicircle of the Alps does the density of population exceed one hundred to the square mile (forty to the square kilometer) across the summit of the mountains, except along the thickly settled littoral of the French and Italian Riviera, where the Maritime Alps sink down to the Mediterranean. Moreover, there the density decreases to half this number a few miles back from the coast, whereas it is maintained across the Karst Plateau in a broad belt from Goerz to Laibach, extending south to Fiume.[1]

Ethnology also reveals the breachlike character of the Julian Alps. Throughout the Venetian plains today, as far west as the Mincio River, the inhabitants are distinguished by a tall stature, rare among pure Italians. Theirs is no doubt the underlying stock of the ancient Venetians, generally considered as a lowland offshoot of the tall Illyrian race, which is found today in Bosnia, Montenegro, and Albania, and which has given some additional inches to the later Slav immigrants.[2] As the Julian Alps were no barrier to the tall Illyrians, neither were they to the Slovenians, the subbranch of the Slav people, who, in the seventh century, pushed up the Save Valley from the east, and today cover the intervening territory down to the Isonzo. At one point they lap over the frontier into Italian territory, but the old district of Aquileia and the Istrian littoral within the Austrian border are still Italian,[3] and still hope to be incorporated in the modern Kingdom of Italy. All this region up to the summit of the Julian Alps forms part of *Italia irredenda*. Its recovery will give the peninsular kingdom a scientific frontier and deprive Austria of her present advantage in offensive and defensive warfare on this border.

THE RHONE VALLEY BREACH.—Different from the low Karst saddle and the marine passage of the Bosporus and Hellespont is the third breach in the mountain barrier, formed by the Rhone-Saône-Doubs groove.

[1] Diercke: *Schul-Atlas* (Brunswick, 1909), 89, 128. Krebs, Norbert: *Länderkunde der oesterreichischen Alpen*, 413.

[2] Ripley, W. Z.: *Races of Europe* (New York, 1910), 255–268.

[3] Diercke: *op. cit.*, "Ethnographical Map," 124.

Like the other two, it connects with the Mediterranean Basin a region of strongly contrasted climatic conditions and, during ancient and mediaeval times, of contrasted economic and industrial development. Remote from the early eastern centers of urban life and progress in the Ægean and the Levantine basins, this Rhone breach came much later upon the historical stage than did the Bosporus-Hellespont. It assumed an important rôle only after the Roman Republic had transferred the big dramatic events of Mediterranean history to the western basin by encircling that basin with a rim of Roman lands. To compensate for this tardy appearance, it has played a peculiarly important part in the history, not only of the Mediterranean, but of all Northwestern Europe. It made Gaul, and later France, one great transit land. Through it Roman civilization penetrated into Gaul, and spread from the radiating passes at the head of the Rhone-Saóne Valley west and north over all that province into Britain, and finally eastward over the Rhine into Germany. The location of the Alpine barrier and the Rhone breach combined to retard the dissemination of Roman culture into Germany, and at length admitted it only in a Gallicized form. During the decline of the Roman Empire, the Rhone breach became in turn the passway for German tribes migrating south. The local population there today reveals in its fairer coloring and tall stature the ethnic infusion of the blonde giants of the north. Linked geographically with the north, the valley became linked ethnically as well with the Teutonic peoples who had drifted along the shelving coastal plains of Germany and France.

Thus the Rhone Valley breach performed the great historical service of uniting the maturer civilization of the warm Mediterranean lands with the growing civilizations around the colder thalassic basins of the English Channel, the North Sea, and the Baltic. These northern seas, in turn, distributed to all their shores the germs of culture brought up from the south. Through the instrumentality of Flemish, Dutch, German, Hanseatic, and English traders they raised the *niveau* of civilization in these retarded northern lands. The similar seed of Greek culture, planted early and thickly on the southern shores of Russia, found no such favorable conditions for transplanting to the Russian north. Many were destroyed by the nomadic invaders from Western Asia before they had well taken root on the Scythian coast. The few that were disseminated northward to the chill plains of Central Russia lost their vitality. Far from the vivifying contact with the sea, impoverished by the lack of fresh accessions, they did not breed true to their type, but languished in dwarfed and flowerless form on the monotonous steppes. The ultimate environment of the Bosporus breach is found in the Valdai Hills, the Volga plains, and the Caspian desert, as that of the Rhone breach is found in the shores of the northern seas.

While the Bosporus-Hellespont breach dates back only to Quarternary times, the Rhone groove has an old geological pedigree. It is not a mere

river valley of erosion, though erosion has carved out some of its minor physiographic features; but it traces back its ancestry to a long marine inlet or strait which in Eocene and Miocene times penetrated northward through a narrow belt of depression between the young folded ranges of the Alps and Jura on the east and the steep escarpment of the old Cevennes Plateau on the west. This sea-arm filled the present valleys of the Rhone, Saóne, and Doubs, and south of the granitic Vosges massif it connected with another inland sea, which in the early Tertiary period occupied the entire Vienna Basin. The slow elevation of the later Miocene closed the strait at its northern end, but left traces of its geological past in the broad gap between the Jura and the southern face of the Vosges, while the Rhone-Saóne depression was converted into a long, pouchlike inlet of the sea. Finally, in the Pliocene, the Rhone-Saóne emerged as it is today, a great river flowing through a narrow plain, fed by the big streams that drain the western slopes of the Alps and Jura, and the short torrents which at close intervals scar the long front of the Cevennes escarpment.[1]

The Rhone System opens a navigable highway straight north from the Mediterranean for 340 miles (550 kilometers), half-way across the base of the Gallo-Iberian peninsula. At its northern end lies the chief hydrographic center of Western Europe. Here it connects with a group of navigable rivers which radiate from its low encircling watershed, and open out natural routes of communication to the Bay of Biscay, the English Channel, the North Sea, and even the Black Sea through the near-by head streams of the Danube River. Scarcely a tidal wave of invasion that swept the western shores of the Black Sea failed to spread up the Danube Valley also and to reach in its ultimate wash that old geological gap between the Vosges and the Jura.

This is the famous Pass of Belfort, known in ancient and mediaeval times as "The Burgundian Gate," a broad gap about 18 miles wide (30 kilometers) lying only 1,138 feet (347 meters) above sea-level. It unites the Rhone groove with the long, fertile rift-valley of the northward-flowing Rhine. Together these formed the chief historical highway of ancient and mediaeval times between the Mediterranean and the North Sea. Migrant hordes, with their wagons and cattle, moving westward from the upper Danube Valley or southward along the Rhine trough from the chill Baltic plains, converged upon this open gateway leading to the sunny shores and rich cities of the Roman Mediterranean. They beat out tracks which were later transformed into Roman roads. Centuries later a canal from l'Isle, the head of navigation on the Doubs, connected that river with the Ill at Muelhausen and the Rhine at Basel.

Meantime a long chain of cities, united by commercial interests, had grown up along the Rhone, Saóne, Doubs, Rhine, and the network of channels in the Rhine Delta to expedite the trade between two contrasted

[1] Chamberlin and Salisbury: *Geology* (New York, 1906), III, 277, 319.

regions of production. The North Sea lands, located on the far outskirts of the ancient civilized world, retarded in their economic and cultural development by geographic remoteness and relatively harsh climatic conditions, commanded nevertheless the abundant raw materials of new, unexploited countries. As growing civilization and trade pricked the desire for luxuries, these raw materials enabled them to make a steady demand for the varied products of that subtropical and industrial Mediterranean world. Therefore Holland and Flanders, lying at the outlets of this Rhine-Rhone highway, were the first states of Northern Europe to feel the concentrated effects of Mediterranean culture, and to produce on these northern shores a replica of Mediterranean Venice, Pisa, and Genoa. In their splendid art, the rich fabrics of their looms, their brocades and tapestries, fine silverwork, printing, and map-making, we trace the Mediterranean lineage of their models.

Geographical companion pieces to the Burgundian Gate are found in the series of low passways which penetrate the hill country filling the older and broader geological gap between the Archean massif of the Vosges and that of the Cevennes Plateau. The long, sluggish Saóne, which is navigable up to this hill country in the so-called Monts Faucilles, affords easy access to these watershed passes. They, in turn, have from the earliest times offered a wide choice of routes for intercourse between the Saóne and the diverging rivers of France which drain outward to the North Sea and the Atlantic. Early migration, conquest, and trade sought them out and used them all. The easiest tracks beaten out by migrant barbarians traversing these uplands or the ones offering the shortest connection with tin-bearing Britain were later followed by Roman roads. Yet later most of them were utilized for water carriage by the system of canals projected by Sully in the sixteenth century. All combined to cement together the various parts of France.

The Saóne connects with the Moselle near the great French fortress of Epernal by a broad, open pass, 1,135 feet (or 346 meters) high, between the Vosges and the Monts Faucilles. So low is the barrier that it has never presented an appreciable obstacle to communication between northern Burgundy and southern Lorraine. Here today one finds the same provincial accent, the same peculiarity of geographical names ending in *-ey*, the same type of rural house, and the same character of inhabitants on both sides of the low watershed.[1] Thirty miles to the west an easy pass route between the Mont de Fourches and the Plateau de Langres connects the Saóne with the Meuse Valley; and yet another crosses the Plateau of Langres at 1,550 feet (473 meters), where canal and railroad now link the Saóne with the Marne. This was the route of the chief Roman road leading northward to the Lower Rhine. It crossed the summit at the ancient town of Andematunnum (Langres), but turning thence across the upland to the Moselle at Tullum (Toul), it followed

[1] Vidal de la Blache: *Géographie de la France* (Paris, 1903), 234–42.

the valley of this river past modern Metz and Trier, and then continued north to the Rhine at Colonia Agrippina, the modern Cologne.

The Roman road to the Seine, which was probably the main route of the tin trade, was important because of this trade and also because the Seine offered the best navigation of all the northern rivers except the Rhine. The road left the Saóne or Arar at the Æduan town of Cabillonum (Chalons-sur-Saóne), turned west past modern Chagny, and mounted the plateau rim now known as the Côte d'Or to the ancient Æduan fortress of Bibracte, later to the nearby Roman town of Augustodunum (Autun). Thence it turned northwest, avoiding the granite massif of the Morvan Plateau, and followed the Yonne Valley across the Auxois plain down to the southern elbow of the Seine. The modern route from the Saóne to the Auxois upland leaves the valley at Dijon and turns up the gorge of the Ouche, which is now traced by highway, the Burgundian Canal, and railroad. But the old road goes back beyond the memory of man. It was the route taken by Caesar in 58 B.C., when he turned aside from his pursuit of the retreating Helvetians to seek the big Æduan town of Bibracte, eighteen miles away, where he hoped to find provisions for his soldiers.[1] Limestone buttresses running out from the base of Mont de Rome-Chateau, which overlooks the route, preserve for us today ruins of bygone habitations or forts, and testify to the importance of this ancient thoroughfare.[2]

Thus the upper Saóne and Doubs command a semicircle of transmontane connections. Midway between these headwater passes and the Mediterranean is the confluence of the Saóne and Rhone. Here lay the ancient city of Lugdunum (Lyons), which for centuries was the heart of Roman Gaul. It commanded not only the whole length of the Rhone-Saóne breach, but also the east course of the Rhone, which opens a narrow and difficult route between the Jura and Savoy Alps to Lake Geneva and the lake plateau of Switzerland. This is the passage which the migrating Helvetians attempted to force in 58 B.C., and which Caesar defended.[3] The swift and often turbulent current of this mountain course of the Rhone, its difficult navigation, and its gorgelike valley afforded a fairly good barrier boundary to the young Roman *provincia*, whose limits had shortly before been pushed northward to the Rhone and Lake Geneva.

This history of the Rhone Valley begins with the founding of the Greek colony of Massilia (Marseilles) in about 600 B.C. The site of the settlement was well chosen. Like many ports designed to exploit the commerce of big river systems, it was located, not at the mouth of the stream, but off to one side, where the constant deposition of deltaic mud could not silt up its harbor and spring floods threaten it with inundation. Such a location Massilia found where the hills of Provence run out as headlands

[1] Caesar *De Bello Gallico* i. 23.

[2] Vidal de la Blache: *op. cit.*, 240.

[3] Caesar *op. cit.* i. 2–10.

into the sea east of the Rhone mouth. These afforded an acropolis for the city and a deep port, protected on the north by the long, bold promontory of the l'Estagne from the destructive blasts of the *mistral*. Small inshore islets to guard the approaches to the harbor, sunny hillsides for vineyards and olive orchards, and the near-by river for inland commerce added all the other elements considered desirable for a Greek colony.[1] The region yielded poor wheat crops, however, so the colonists were compelled to "trust more to the resources of the sea than of the land, and avail themselves, in preference, of their excellent position for commerce," as Strabo tells us.[2]

The southern approach to the Rhone Valley breach was made either by sea or by land. The shallow waters of the Gulf of Lyons, the weak tides of the Mediterranean, and the heavy burden of silt transported by the swift-flowing Rhone and Durance, all combined to build up a large deltaic plain, through which wind the tortuous courses of the Rhone distributaries. Like the outlets of the Nile, these varied in number from two to five at different periods and shifted their location.[3] Access to them was difficult. The flat, alluvial shore was often difficult to discern in bad weather, as it lacked the bold sea-marks on which the Mediterranean sailor was wont to rely. The debouchment channels were constantly obstructed by the mud deposits at their mouths. As early as 101 B.C. Caius Marius, who probably took his troops by sea from some northern Roman port for the campaign against the Cimbri, found it necessary to construct a navigable channel through the lagoons and half-silted distributaries from the eastern outlet of the Rhone to a point above the delta, where the road crossed the river.[4] These *fossae Marianae* he gave to the people of Massilia in return for their aid against the invaders. The city made revenue out of the canal by levying a toll on all boats using it.[5] But the silting process in time impaired its usefulness, and threatened once more to block the entrance. Further obstacles to navigation were found in the powerful current of the Rhone, and the *mistral*, called by the ancients "the black north," which swept down the valley.

Ancient traffic on the Rhone seems to have been considerable, despite the difficulties of navigation. The Massilians were not the only ones engaged in this river commerce. When Hannibal in 218 B.C. crossed the Rhone on his march from Spain to Italy, he was able to buy numerous dugout canoes and boats from the natives, who used them in their extensive sea traffic.[6] Massilia was the distributing center for the tin which found its way southward across Gaul from Britain[7] and probably also from mines in the Vilaine Valley of Southeastern Brittany, where ancient workings have been found.[8] Diodorus Siculus states that the tin of

[1] Vidal de la Blache: *op. cit.*, 341, 344, 345.
[2] Strabo iv. 1. 5.
[3] Strabo iv. 1. 8.
[4] Heitland, W. E.: *op. cit.*, II, 372.
[5] Strabo iv. 1. 8.
[6] Polybius *Histories* iii. 42.
[7] Strabo iii. 2. 9.
[8] Vidal de la Blache: *op. cit.*, 20–21.

Cornwall was collected for export on a small inshore islet of the British coast, a typical maritime market place. There it was purchased by merchants who took it over to Gaul, and transported it on horses, a thirty days' journey across the country, to the mouth of the Rhone.[1] The Massiliots set up merchantile factories in the Gallic towns to forward the British tin to the coast, together with the raw products of the interior. In exchange, they supplied the back country with fish, salt, olive oil, wine, bronze utensils, and pottery,[2] some of which undoubtedly found their way to that indented Cornwall peninsula first known to the ancients as the Cassiterides Islands.[3] Through the Rhone Valley breach the cruder elements of Hellenic civilization thus trickled into Northern Europe, while the Greek language, alphabet, and economic methods were disseminated among the neighboring Gauls of the long Massiliot littoral.

The Rhone Valley breach is approached also by two land routes, one from Italy and one from Spain, which respectively turn the mountain barrier where the Maritime Alps and the eastern Pyrenees run out into the Mediterranean. These narrow passways between mountain and sea have always opened lines both of trade and of attack. Hence Massilia fringed them with her subsidiary colonies.[4] She lined the Gulf of Lyons from Emporiae and Rhoda (modern Rosas) on the Spanish coast of the Pyrenees, around to Olbia (Eoube) and the Iles d'Hyeros on the east; farther on, Antipolis or Antibes, Nicaea or Nice, and Portus Monoeci or Monaco, strung along the rocky seaboard of the Maritime Alps, opposed the depredations of the mountaineers and maintained the connections of Massilia with its ally Rome.[5]

These routes became important also to the Romans after their acquisition of Spain from Carthage in 201 B.C. Hence their first systematic campaigns against the Alpine tribes and their conquest of the Rhone Valley were both inaugurated by attacks on the mountaineers flanking this route, the valiant Salluvii of the Maritime Alps and their Ligurian neighbors of the western Apennines. Like all highland tribes, they took advantage of their strategic location to maintain a system of pillage by land and sea, to block Roman traffic with Massilia and Spain, and even to obstruct the passage of Roman armies. The geographical relief of the country fought for them. It enabled them to maintain a guerilla warfare in intensity and duration out of all proportion to their numerical strength, after the manner of primitive mountain people the world over. In 125 B.C., after a conflict of eighty years, all that the Romans could force from the barbarians was a coastal strip, averaging a little over a mile in width, for purposes of a highway.[6] The ceded strip was transferred to the Massiliots,

[1] Diodorus Siculus v. 22.

[2] Curtius, Ernst: *op. cit.*, I, 482.

[3] Strabo iii. 5. 11.

[4] Grote: *History of Greece* (London, 1854), III, 538.

[5] Strabo iv. 1. 5.

[6] Strabo iv. 6. 3.

who undertook to construct and maintain the coast road, since it united their settlements. Beginning at Genoa, where it connected with the Via Aurelia, the road ran west across the roots of the Alps between mountain and sea as far as the modern Frejus (Forum Julii). There it left the coast, which runs out southward into a blunt peninsula, and turning up the valley of the Argeus River, continued westward along a longitudinal groove between parallel hill ranges. Where it emerged upon the alluvial plain of the Rhone, just north of Massilia, the Romans built the garrison town of Aquae Sextiae (Aix) to guard the road.[1] This Massiliot highway was later replaced by the Via Julia Augusta in the early days of the Empire. Centuries afterward, in 1807, it was revived by Napoleon in the famous Cornice Road, which he built to connect France with his short-lived Kingdom of Italy. Thus geography turned back to the history of the imperial Caesars for a page to insert in the history of the great French Emperor.

From the military base at Aquae Sextiae, which commanded land and sea connection with Italy, began the Roman conquest of the Rhone Valley in 125 B.C. First the Salluvii between the Durance River and the sea were subdued, then their northern neighbors, the Vocontii, and finally in 122 B.C. the powerful Celtic tribes of the Allobroges, who inhabited the rich valley of the Isara (Isère) and the country north to Lake Lemanus (Geneva). The powerful Averni of the Cevennes Plateau, who had lent assistance to Allobroges, were forced to cede to Rome all the short south-eastern slope of their highlands to the Rhone and the Mediterranean as far west as Tolosa (Toulouse) on the Garonne River,[2] a territory comprised in the later French province of Languedoc. Thus practically all the Rhone Valley, north to the Saóne confluence and to Lake Geneva, was comprised in the Roman province, except the coastal strip tributary to its ally Massilia. The geographic reasons are clear. The valleys of the Durance and Isère opened avenues of approach to the only two practical passes over the western Alps, the Mons Matrona or Mont Genevre at an altitude of 6,080 feet (1,853 meters), and the Little St. Bernard at 7,075 feet (2,157 meters). The latter was the unguarded door, hardly feasible for an army, which probably admitted Hannibal's forces into Italy, though it collected a frightful toll of life from his men and animals. Hence Hannibal's line of march, by the Pyrenean coast road, the valleys of the Rhone and Isère, and the Little St. Bernard Pass, determined with some accuracy the limits of early Roman expansion into Gaul.

On this point the first Roman road-building across the Rhone is instructive. From Arelate (Arles) at the head of the delta, where the passage of the river was easiest and where therefore the Massiliot road had its terminus, the Romans ran the Via Domitia westward around the Gulf of Lyons, through Narbo (Narbonne), capital of the new province,

[1] Strabo iv. 1. 5.

[2] Mommsen: *op. cit.*, III, 205–7.

and thence southward over the last spur of the Pyrenees into Spain. Here the massive form of the Pyrenees, stripping off its surplus folds before plunging into the sea, thrusts out an arm to the Mediterranean. This arm is the Alberes range, a single bold ridge deeply notched by the Col du Pertus (951 feet or 290 meters), which opens a low passway between the maritime plains of Roussillon in France and those of Ampurdan in Spain.[1] The sea-front of the Pyrenees forms a series of mountain headlands towering high above the fretting waves. It was enough to daunt the Roman road-builders, for it taxed the skill of the modern engineers, who by means of tunnels and galleries put through the coast railway here in 1880. The ancient gate of the Pyrenees lay, therefore, 7 miles back from the sea. Massilia had seen danger in this open door, and therefore planted along its southern approach several outpost colonies as bulwarks against Iberian invasion. Rome had seen it too, when the Carthaginians began to establish a new empire in Spain, and therefore in 225 B.C. exacted from the Carthaginian governor a pledge that he would make the Ebro River the northern limit of his conquests in Spain.[2] But when Hannibal was ready to invade Italy, he crossed the Pyrenees by the Col du Pertus,[3] traversed Southern Gaul, and was already over the Rhone before the Roman army under Publius Scipio had landed in Massilia. From this time on through ancient and mediaeval history the Col du Pertus was a passway for migration and conquest.

It is significant of the purely Mediterranean outlook of the Roman Republic that it began its inland expansion up the Rhone Valley breach only under the spur of necessity. The century-long rivalry with Carthage kept it facing seaward, and forced it out of its peninsular isolation into wide maritime contact and dominion. Its great historical events were staged on the coasts. The hinterlands of the three surrounding continents as yet counted for nothing. Conquest of the lower Rhone Valley, the initial step of their inland expansion, was begun only after the annexation of Carthage in 146 B.C. had made the western Mediterranean basin a Roman lake, and after the Adriatic, the Ionian, and Ægean seas with their bordering lands had likewise been incorporated in the empire of the Republic. Moreover, the Provincia Romana of Gaul, located between the western Alps, the Cevennes escarpment, and the Pyrenees, was Mediterranean in its climate, its natural products, and also to some extent in its civilization, owing to the strong Hellenizing influences which for nearly five centuries had been emanating from Massilia. The province was organized and annexed in 121 B.C. Further expansion beyond the climatic limit defined by the Rhone elbow at the Saône confluence had to wait till 58 B.C., or over sixty years.

Meantime the *provincia* was having the typical experiences of a border district on an exposed frontier. While other Roman provinces like Sicily

[1] Vidal de la Blache: *op. cit.*, 355–56.

[2] Heitland: *op. cit.*, II, 223.

[3] Polybius *op. cit.* iii. 9; xxi. 23, 24.

and Spain suffered from local revolts against an oppressive government, this one alone suffered from foreign incursions. Therein it anticipated by some five hundred years the similar historical events of Pannonia and the Julian Alps, growing out of similar geographic conditions. It became in effect a Marchland, after the order of the later German *Mark;* and it duplicated the history. First a border district of defense, it passed suddenly to a more brilliant rôle as a base for conquest and expansion. Often a geographical handicap may be converted into a geographical opportunity. It is a matter of tipping the scales.

Rome secured her end of the Rhone Valley breach not a moment too soon. Immediately she began to encounter here a persistent stream of Germanic expansion, which selected this easy path to the sunny Mediterranean lands. Hither, in 109 B.C., came the Cimbri, who four years earlier had been ordered off from that half-open door of the Julian Alps. The door was wide open here, so they defeated the Roman army somewhere in the Rhone Valley. They returned in 105 B.C., hurled aside the Roman army stationed at Arausio (Orange) on the lower Rhone to obstruct their course, and passed on victorious by the near-by Pyrenean gate into Spain. They wandered in Spain and Gaul for two or three years, but were soon back, nosing like hungry dogs about the doors of Italy.[1] This time (102 B.C.) the Cimbri found a way to the Po Valley by the Brenner Pass (4,470 feet, 1,362 meters) over the Central Alps; but their allies, the Teutons and Ambrones, came down the Rhone Valley. Caius Marius, Rome's great general, four times in succession elected consul in anticipation of this danger on the Rhone, was sent to oppose them. He let the barbarians trek past his camp on the lower Isère, where he had taken his stand to head them off from the western Alpine passes; but near Aquae Sextiae (Aix), at the entrance to the Massiliot coast road to Italy, he stopped their advance by a crushing defeat in 101 B.C.

The real points of danger for Rome lay in that semicircle of passes crossing the watershed of the upper Saóne and Doubs. The country between the Saóne and the Rhine was held by the Sequani, who thus commanded the Burgundian Gate; that between the Saóne and the plateau course of the Loire and Seine systems was occupied by the Ædui, who thus controlled the western passes. Rivalry existed between the tribes, because each claimed exclusive right to the Saóne and especially to the tolls levied on passing vessels.[2] The Romans, stretching their sphere of influence to this strategic locality where lay the keys to the Rhone Valley door, made an alliance with the Ædui, and enabled them to exclude the Sequani from the profitable Saóne commerce. The Sequani, in turn, invited in Ariovistus and his German horde who dwelt just across the Rhine, and in 62 B.C. by their assistance defeated the Ædui. The bars of the Burgundian Gate were down. The Germans kept pouring into

[1] Heitland: *op. cit.*, II, 363–66, 372–73.

[2] Strabo iv. 3. 2.

Gaul and settling in the Sequani land. Ariovistus had a German province there by 58 B.C., when Caesar, adopting an aggressive policy, moved up the Saóne Valley to prevent the Helvetian invasion. This accomplished, he prepared to attack the Germans, who showed no inclination to withdraw from their newly acquired territory. He advanced up the Doubs Valley and seized the Sequanian fortified town of Vesontio, which occupied a strong location within a circular loop of the Doubs and which survives today as the great fortress of Besançon. From this town as a military base he attacked the Germans near the Rhine and drove them across the river out of Gaul. That autumn the army of Caesar went into winter quarters in the Sequanian territory.[1] Rome held the Burgundian Gate.

Thus began the conquest of Gaul. The significance of the movement for the Romans lay in the complete control of the Rhone Valley breach and its inland approaches; in the protrusion of the frontier far beyond the danger line found in that semicircle of watershed passes; and in the inland extension of Roman trade routes. For the world at large it meant the advance of historical events beyond the narrow rim of the Mediterranean Basin to the contrasted Atlantic lands of Europe.

The conquests of Caesar checked for a time the streams of barbarian invasion. The decline of the Empire saw them surging on again. The Germans repeated the history of Ariovistus and his hordes. They settled first in the elbow of the Rhine, like the Allemani and the Burgundi, then moved across the river and through the Burgundian Gate into the Doubs and Saóne valleys. Others followed the course of the Cimbri, moved westward by the Belgian plain to the Meuse and then up its valley to the Saóne passes. In the fifth and early sixth century the Burgundians occupied all the old Sequanian and much of the Æduan territory; in fact all the basin of the Saóne and middle Rhone. There, strong in their strategic location, their mountain barrier, and their geographic unity, they maintained themselves as an independent kingdom for nearly a hundred years, till in 534 they were conquered by the Franks.[2]

The expansion of the Frankish tribes from their base in the northern plains of Gaul is instructive from the geographical standpoint. They swung around to the west of the Cevennes Plateau and in 511, by the conquest of nearly all Aquitaine from the West Goths, they pushed their boundary up the Garonne Valley to the Gap of Carcasonne; sweeping also down the Rhone Valley, they forced their frontier toward the Mediterranean as far as Orange, where the Cimbri had defeated the Romans. But they were still shut out from the Mediterranean. That old coastal belt between the Maritime Alps and the Pyrenees, which expanding Rome had first detached from Celtic Gaul, was still detached from this young Frankish Gaul. Provence, that earliest *provincia romana* of the Mediterranean seaboard and the Durance Valley, formed an arm of that East Gothic kingdom of Theodoric. The rest of the coastal strip between

[1] Caesar *op. cit.* i. 31–54.

[2] Hodgkin, T.: *op. cit.*, III, 357–58, 592.

the Rhone Delta and the Pyrenees, called Septimania or Gothia, formed a similar arm, which the Spanish kingdom of the West Goths thrust out to grasp hands as it were across the turbid current of the Rhone with its brother nation and overlord of the Italian peninsula. Thus these twin Gothic kingdoms were geographically the exact successors of Rome in 100 B.C. when it had united Italy and Spain.[1] The coastal strip of Mediterranean Gaul was the link between.

The link was too frail to resist the seaward expansion of the Frankish kingdom. It gave way in Provence, which was annexed to the dominion of Clovis in 536. Those interlacing headstreams along the granitic highlands of the Vosges and Cevennes, knitting together the river valleys of France, rounded out to its logical limits the territory of that first great imperial expansionist of the North Germans. Septimania, held by the eastern Pyrenean passes, remained part of the Spanish kingdom of the West Goths till 719, when it became part of the Spanish caliphate of the Saracens, and so continued with a few intermissions till 797. Again the Pyrenean Gap and the Rhone Valley were historically linked. During the Saracen conquest of Spain, Christian refugees fled across the eastern Pyrenees to the protection of this transmontane province of Septimania, and spread their Catalan Spanish speech as far as the Courbières Range, on whose last low shelf stands Narbonne above the alluvial flats of the Aude River. Their respite was short; their asylum wall too low. In a few years reconnoitering bands of Saracens sought out the eastern passes of the Pyrenees. Then came a great Saracen army in 719, and captured and fortified Narbonne as a base for future campaigns; Narbonne, which the Romans had built to command the Gap of Carcasonne and the coast road to the Rhone.[2] Defeated in their attempts to conquer Aquitaine, the Saracens turned toward the Rhone. They took Avignon in 730. For a few years Nimes and Arles were in their power; but even in that short period they injected new life into the Rhone Valley commerce, kept their merchantmen hovering about the coast, and made their profit as the sea traders of Arabian Yemen have known how to do ever since; in rafts and dugouts they crossed the Strait of Bab-el-Mandeb to the market land of Punt and brought back Indian pearls and jewels to deck their Queen of Sheba. The outpoured flood of conquest which spread from Arabia to the Pyrenees had now spent itself. The occupation of Southern Gaul was the last weak lapping of the tide before the ebb. Narbonne was captured from the Saracens in 752 by Pepin le Bref; but it had to be retaken in 797, and finally was embodied in the domain of Charlemagne. At the same time (777–801), the Emperor advanced his frontier over the southern slope of the Pyrenees and occupied the Spanish March as an outpost against the Saracens.[3] Thus he restored the old union of Northeastern Spain with

[1] Freeman, E. A.: *op. cit.*, 121–23.

[2] Coppee, H.: *History of the Moors in Spain* (Boston, 1881), I, 418–22; II, 17.

[3] Freeman, E. A.: *op. cit.*, 125.

the coastal province Septimania, and repeated the history of Massiliot Gaul.

The threefold division of the Carolingian Empire by the treaty of Verdun (843) is explicable only in the light of the Rhone Valley breach. This geographical fact is the key to what otherwise appears to be an arbitrary and erratic allotment of the territory to the three heirs. The division left to Charles the major part of what we are wont to call France, or the kingdom of the West Franks; to Louis, the kingdom of the East Franks, which might be called the big nucleus of modern Germany; to Lothair it gave Italy and "a long narrow strip of territory between the dominions of his Eastern and Western brothers," Freeman states, and then adds in explanation: "Between these two states the policy of the ninth century instinctively put a barrier."[1]

Geography admits no place for instinct in its interpretation of history. It looks for concrete and tangible causes. In this particular case it observes that the problematical strip of Lothair's territory comprised the whole Rhone-Saóne-Doubs Valley, the Burgundian Gate with the elbow of the Rhine, the two northern passes of the hill country of the Monts Faucilles and Mont des Fourches to the Moselle and the Meuse, all the country drained by these two rivers, and the valley of the Rhine below the confluence of the Moselle at Coblenz. In other words, Lothair, to compensate himself for the small territory of Northern and Central Italy, demanded the whole stretch of that natural transit belt which crossed Europe from Marseilles northward to Cologne, Aix, and the mouths of the Rhine, the Meuse, and the Scheldt. This he held in its entirety except at two points. The West Frankish kingdom retained the Langres Pass, where the original Roman road had crossed the watershed; and it also thrust its frontier across the Saóne at Chalon-sur-Saóne in order to keep the important valley terminus of the ancient Æduan and Roman highway down from Autun. But Lothair's strip, in compensation, bent sharply west from Lyons far up on the Cevennes Plateau, in order to include the city of Roanne (Rodumna) on the Loire, the terminus of the old Roman road which ran west to Bordeaux on the Garonne estuary. Though all these ancient Roman highways had undoubtedly degenerated into mere tracks, they still sufficed to direct the commerce of the Middle Ages.

A traffic zone hardly furnishes a sound basis for a political territory, though it may yield a generous revenue. This transit strip constituting the continental part of Lothair's kingdom proved its artificial character by its rapid dissolution.[2] The northern half, comprising the valleys of the Meuse, the Moselle, and the Rhine, was absorbed by the East Frankish kingdom. Out of the remaining ruins emerged once more, in 887, the independent kingdom of Burgundy, a geographical unit with natural boundaries of mountain and sea to protect its frontiers; with the Rhone-Saóne-Doubs

[1] Freeman, E. A.: *op. cit.*, 140.

[2] Lavisse: *Histoire de France* (Paris, 1901), II, Part II, 4.

System penetrating every part of its area, like a great artery, to unify its national life; with the control of the Burgundian Gate, the northern passes, and the Alpine coast road to Italy, to give it weight in the political councils of Western Europe. Its strategic location tended to compensate for its lack of area. It stood in the center of the balance and could throw its weight on one side or the other. Through this power it was able to maintain its independence till 1032, when it became a fief of the German Empire. Then the whole stretch of the Rhone-Rhine groove was politically united. The influence of the through commerce is indicated by the rise here of numerous free cities, Besançon, Lyons, Orange, Arles, and Marseilles, which controlled all the foci of trade till the fourteenth century, and maintained the importance of this vassal state of Burgundy. Until 1365 the mediaeval German kaiser went to Arles to be crowned king of Burgundy as he went to Rome to be crowned emperor of the Holy Roman Empire.

The later history of Burgundy recites the gradual absorption of this "middle kingdom," as the old chronicles called it, by the modern kingdom of France. Early in the fourteenth century its voracious western neighbor began to gnaw at its western frontier, taking a bite here and there, till by 1378 it had swallowed up the southern Rhone Valley from the Mediterranean to Lyons. The northern part of Burgundy, which was more closely linked with Germany through the Burgundian Gate and the Lorraine passes, was able longer to resist French expansion. Nevertheless, in another hundred years, by 1477, it had shrunk to the free county of Burgundy or the Franche Comté, a small territory comprising the valleys of the upper Saóne and Doubs, which passed to France in the conquest of Louis XIV.[1]

The Rhone Valley breach opened a path of conquest for the military Franks from the north to the coast provinces of Languedoc and Provence, just as later it facilitated the expansion of the French kingdom to the Mediterranean coast and enabled it to round out its territory to its natural frontier. The breach has given to this stretch of coast a unique importance as the only littoral in the western Mediterranean that commands easy connection with a continental hinterland, and as the southern outlet of a great plexus of northern land routes.

Marseilles, which has long overshadowed its mediaeval rival Arles, is the only seaport of the Rhone Valley. It has therefore concentrated upon itself all the exports of Northwestern Europe which seek the market of Africa, the Levant, Eastern Asia, and Australia; it gathers in return the wheat of Russia, the oil seeds of India and Africa, the wines and dried fruits of the Mediterranean, the teas and spices of the Far East.[2] The variety of products from distant sources which pass through the harbor of Marseilles is symbolic of the peoples, tongues, and civilizations that have moved along the Rhone Valley thoroughfare since the dawn of history.

[1] Freeman, E. A.: *op. cit.*, 141, 148, 150, 194; map plates, XVIII–XXV.

[2] Chisholm, George G.: *Compendium of the Geography of Europe* (London, 1899), I, 429.

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THE PRINCIPLES OF GEOGRAPHICAL DESCRIPTION

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CONTENTS

OBJECT OF ESSAY.—The object of this essay is to bring together in consecutive form certain principles of geographical description that in recent years have come to occupy more and more of my attention, and that have been published less completely elsewhere.[1] Physiographic topics

[1] "The Systematic Description of Land Forms," *Geogr. Journ.*, XXIV (1909), 300-318; "Experiments in Geographical Description," *Bull. Amer. Geogr. Soc.*, XLII (1910), 401-35; *Scot. Geogr. Mag.*, XXVI (1910), 561-86; "The Colorado Front Range, A Study in Physiographic Presentation," *Ann. Assoc. Amer. Geogr.*, I (1912), 21-84; "Relation of Geography to Geology," *Bull. Geol. Soc. Amer.*, XXIII (1912), 93-124; "Der Valdarno, eine Darstellungsstudie," *Zeitschr. Ges. f. Erdk. Berlin* (1914), 585-665.

are more fully treated than others, because I am more familiar with them. Ontographic topics, briefly touched upon in the later sections, deserve extended statement, which it is hoped they may receive from some geographer who, while not altogether neglecting the physiographic half of his science, specializes in the other half. More important still is the combined treatment of physiographic and ontographic topics in full-fledged geographic presentation, to which some pages are devoted near the end of this essay. Let it be pointed out at once that the object of the ontographic sections is not to show the content of that half of geography, but to show that in the treatment of ontographic problems the same principles should be observed as those which guide the treatment of physiographic problems.

This essay was written for presentation at the Princeton meeting of our Association in December, 1913, and was submitted to censors during my absence on the Pacific in the year 1914. It was revised on my return in view of comments by the censors, and resubmitted for publication early in 1915; but as a change of editors had been made in the meantime, the essay was again submitted to censors, and on its second return to me it has again been revised. My thanks are here tendered to the censors; their comments have been serviceable in aiding me to make my intention clear.

Regional Description the Goal.—The description of existing landscapes, districts, and regions of the earth's surface is the goal toward which other phases of geographical study, whether presented as personal narrative, historical review, analytical discussion, or systematic arrangement, all lead. Regional description is not systematic in the sense of describing things of a kind together, for it treats them in their unsystematic natural grouping. It is not analytical, in the sense of striving to find out the origin and meaning of existing facts, for it uses already discovered origins and meanings as an aid in setting forth the facts as they exist. It is not historical, either in the sense of tracing the progress of advancing knowledge regarding an area, or in the sense of following the discovery, settlement, and development of the area, though it may use the results of historical study in giving a better account of actual conditions. It is not narrative, for it seeks to present persistent and objective facts rather than temporary and subjective personal experiences. Regional geography is however synthetic in combining the helpful results of all other modes of presentation in a vivid description of a part of the earth's surface, so that all the geographical elements and activities there occurring, inorganic and organic, shall be appreciated in their true spacial relations. There are of course many other methods of geographical presentation than the five mentioned above, and these five and various others may be combined in any way that a writer desires; but it still remains true that pure regional geography is the final object of a geographer's efforts. For the purposes of the present article, especial attention will be given to analytical and

systematic methods, because they furnish so indispensable a preparation for regional presentation: these methods will be here applied to physiographic problems, for the reason already stated; but it is believed that the principles thus exemplified hold good in ontographic and geographic problems as well.

Whatever be the area included in a regional description it can be known only by the summing up of many smaller areas, each of which has been actually seen as a "landscape"—in the larger sense of the word—by an observer on the ground. In so far as the larger features of an extensive area are treated, they can be described only because their parts have been seen to persist through many contiguous small areas. Even the study of a whole continent must begin with the study of its locally visible landscapes: not until they have all been seen can the continent be fully known. Even when all of them have been seen, it is still a difficult art to select the general features and to present them effectively in a brief regional description. I believe that this art can be better acquired and better practised, if the principles on which it is based are clearly understood; the purpose of this paper is therefore to consider the fundamental principles in accordance with which local and general regional descriptions should be prepared.

Observed Facts and Their Mental Counterparts.—When an observer describes "a forest-covered headland with an outstanding island between two bays, at the head of the larger one of which stands a city," this implies that he already possesses certain concepts which are in their essential elements the mental counterparts of the actual features that he has seen, and which are summoned to his mind by the terms, forest, headland, island, bay, and city. If the observer publishes a statement of this kind, he thereby implies that his readers possess similar concepts, which will be brought to mind by the terms that he employs.

If another observer notes the occurrence of "a long, high ridge bearing a coniferous forest and interrupted by a steep, narrow gorge through which flows a large and rapid river, and near which lies a village of wooden houses arranged on a rectangular plan," this implies that his mental concept of a ridge represents it as variable in length and height, and that the ridge which he noted is longer and higher than certain other ridges of which he has knowledge; that his concept of a forest is variable as to the kind of trees that compose it; that his concept of a gorge may vary as to depth and breadth, and so on. If he publishes a description of this kind, he assumes that his readers have variable concepts like his own, and that they and he use the same adjectives to indicate the various values through which the concepts may range.

In other words, the physiographic and ontographic things mentioned in any geographical description must be stated in terms of their previously conceived and named mental counterparts, which are assumed to be the common property of the writer and his readers. The counterparts and

their names may be called the mental equipment or outfit of a geographer, whether he be a reader or a writer. The principle here involved is surely no new idea, yet it seems to be imperfectly recognized in geographical investigation. A friend has called my attention to its general statement more than a century ago in the preface to Kerr's translation of Lavoisier's *Elements of Chemistry* (4th ed.; Edinburgh, 1799):

> Every branch of physical science must consist of three things; the series of facts which are the objects of the science; the ideas which represent these facts; and the words by which these ideas are expressed. . . . . The word ought to produce the idea, and the idea to be a picture of the fact. . . . . We cannot improve the language of any science, without at the same time improving the science itself; neither can we, on the other hand, improve a science, without improving the language or nomenclature which belongs to it.

The hundred years since these lines were written will doubtless afford many similar statements.

Value of an Extended Mental Equipment.—It is important that a geographer who takes the part of an observer and a describer should possess an extended mental equipment consisting of a great variety of geographical concepts, ontographic as well as physiographic, because it is much easier consciously to see—or apperceive—what one looks at, if it matches an already familiar mental concept, than if it finds no such match. It is further important that the mental concepts of all the more important kinds of geographical things should have names, in most cases in the form of nouns with qualifying adjectives, because it is so much easier to tell what one sees if a familiar name is ready for use in the telling. This is equally important for a geographer who takes the part of a reader, for reading is slow work when the reader encounters many unfamiliar words which do not readily call to mind the concepts that belong to them. Indeed, unless the mental equipments of the writer and the reader have a corresponding terminology, the writer's descriptions will be Greek to the reader, in whatever language they are set forth.

Evidently then the acquisition of a good mental equipment in every branch of geography is an important matter for a well-trained geographer, be he an explorer and writer or a stay-at-home and reader, or both. Furthermore, inasmuch as the equipments of concepts and names, as recommended and employed in different quarters, are not in all respects alike, a geographer must exercise care in selecting one that shall suit his preference and serve his purpose, so that he may thereafter use it permanently and consistently. Let us therefore consider how these mental equipments differ, how they are acquired, and how a geographer may best make choice among them.

Differences in Mental Equipments.—Mental geographical equipments differ in grade between elementary and advanced. The elementary should not be of such nature that it must be discarded when the advanced is learned; the first should be capable of expansion into the second.

Equipments vary in style between popular and scientific. While the popular cannot be so extended or so precise as the scientific, the scientific should as far as practicable utilize the popular. Technical, scientific concepts and terms should as a rule be introduced only to represent things for which the popular equipment has no adequate representatives. When it is desired to translate technical terms into popular form, it is best done by paraphrases, in which general intelligibility is gained at the expense of brevity.

Equipments differ in completeness. An equipment or outfit is incomplete when it does not include counterparts of a sufficient variety of geographical phenomena; thus an elementary popular outfit that does not include such concepts and terms as lake, desert, prairie, glacier, tides, and village, would be seriously incomplete, for it would fail to provide counterparts and names for commonly observed features. Likewise an advanced scientific equipment would be incomplete if it did not include such concepts, with terms or phrases for their description, as a maturely dissected cuesta of low relief and indistinct outline; an imminent and a recent river capture; a mild winter climate, in which the diurnal temperature range is rarely or never inverted by the cyclonic temperature range; an invading flora on a surface covered by a recent fall of volcanic ash; related but in part specifically diverse faunae on the surviving islands of a partly submerged region; a decadent human population restricted to an unfavorable area.

Equipments may differ in principle. One may be based only on observational experience with geographical facts, and in such a scheme every mental concept will correspond to an observed example or to the averaged value of several similar examples: an equipment of this kind may be called empirical. Another may be based on theoretical views as to the origin or evolution of geographical facts; its concepts will not ordinarily correspond precisely to observed examples, but will be generalized in view of their supposed origin; an equipment of this kind may be called genetic, rational, or explanatory. Recent studies in ecological botany offer excellent examples of concepts that belong in an equipment of the latter kind.

Equipments vary greatly in the complexity of their mental preparation. The empirical equipment employs few mental processes, chiefly observation, memory, comparison, and generalization; while the explanatory equipment employs, besides these, several more, such as invention, deduction, confrontation, revision, and critical judgment, all of which are not too many in a subject as difficult as the development of a rational equipment for the accurate and intelligible description of landscapes and regions. The problems of anthropogeography offer abundant examples of the advance in the last half century from the earlier empirical methods to the modern explanatory method, in which many mental faculties find full exercise.

Equipments vary in precision or definiteness. Most terms that are taken from popular usage, like valley and mountain, forest and village, represent concepts that are indefinite to the point of vagueness. Many qualifying adjectives or phrases, not having been standardized, are also inevitably indefinite: a mountain of medium height will be qualified as high or low according to its surrounding; a village may be described as large or small according to the previous limited experience of the observer, instead of according to some generally accepted standard. Most explanatory physiographic terms are, as will be shown more fully below, of fairly definite value, as immature cirque, mature sea cliff, obsequent fault-line scarp: ontographic readers can doubtless suggest equally definite explanatory terms in their half of our subject. When a definite explanatory terminology, corresponding to an extended series of completely genetic concepts, is correctly employed by an experienced observer, the resulting description not only will be accurate but it will also be fully and truthfully intelligible to a similarly trained reader.

Equipments vary in consistency. Thus an equipment may be purely empirical, in that it carefully avoids all concepts based on theoretical views; or purely explanatory, in that it excludes all concepts that are not based on theoretical views. On the other hand, an equipment may be a careless, nondescript mixture of different schemes, and perhaps unconsciously include concepts of any and every kind.

As this discussion is addressed to mature geographers, no further consideration need be given to elementary, popular, or incomplete outfits. In what follows attention will be directed chiefly to a comparison of advanced, technical, and complete outfits of various kinds; illustrative examples will be chosen for the most part from land forms, not because other divisions of geography cannot afford equally good examples, but because of my limited experience with them.

Inconsistency of Empirical and of Explanatory Equipments.—The most pronounced contrast between the two chief kinds—empirical and explanatory—of advanced, technical, and complete equipments springs from the difference in the principles on which they are based: one is satisfied to describe without explaining; the other is dissatisfied unless explanation is included in description. But the most determined empiricist does not limit his mental equipment to the counterparts of facts of his own observation: he necessarily forms many concepts from the descriptions of facts prepared by others. If an outfit is consistently empirical, no theoretical considerations should be allowed to enter it. True, similar observations may be grouped together and their values averaged, so that the concept comes to represent an ideal type and not any special occurrence; but it may happen that a type thus formed, not guided by the deeper insight of theory, includes forms of merely superficial similarity, and in such cases the ideal type will not be based on good induction. Errors of this kind constitute dangers in the empirical scheme. Furthermore, such

has been the success of the explanatory school that few empiricists do not today unintentionally or half-consciously include some explanatory concepts, such as those corresponding to the explanatory terms, volcano, delta, and moraine, in their outfit, which thus becomes inconsistent or nondescript.

On the other hand, the most ambitious rationalist must recognize that he cannot as yet form satisfactory genetic concepts for all the forms that he sees; he must therefore sometimes fall back on an empirical terminology, especially in the account of small things; and hence his outfit also is inconsistent; but he is usually conscious of the inconsistency and strives to overcome it, while the inconsistent empiricist is usually unconscious of, or at least indifferent to, his inconsistency.

The relative value of the two kinds of equipment can be best tested by describing a number of dissimilar districts, first in a purely empirical style, then in a purely explanatory style. This exercise may be warmly commended to geographers who are uncertain as to which kind of description to use, and particularly to young geographers who are about to make choice of the kind of description that they propose to employ later. It is only through such competitive experiment that individual opinion as to the merits of different methods can be judiciously formed, but the experiment should not be made until both methods of description are understood.

Relative Completeness of Empirical and of Explanatory Equipments.—Two geographers of equal capacity, one an empiricist, the other a rationalist, might have equally careful training, each in his own school, and equally extended experience in traveling over the world; but their resulting mental equipments would not be equal in respect to completeness. The equipment of the empiricist would be limited to concepts formed as the counterparts of observed and generalized facts; that of the rationalist would be extended far beyond the explanatory counterparts of observed facts, by the addition of a great number of possible counterparts of unseen facts, deduced from the general theoretical explanations under which the observed facts belong.

For example, the rationalistic physiographer can easily—in imagination—follow the theoretical changes in the form of a coastal plain consisting of a heavy series of weak and strong strata, during its slow elevation and slower degradation to the end of a first cycle of erosion, as in the two background blocks of Fig. 1; he can then imagine a new elevation (indicated here only by the revival of the streams), whereby the truncated plain of the first cycle will be introduced into a second cycle, at a certain stage of which unconsumed "bridges" of weak strata will connect the adjoining, incompletely developed cuestas and separate the valley-heads of the revived subsequent streams, as in the middle part of Fig. 1. He will thus outstrip observation, for actual examples of this eminently possible kind of form have not yet, as far as I have read, been discovered: cuestas

are usually separated by continuous subsequent valleys, as in the foreground of Fig. 1. An observer familiar with this theoretical scheme will surely be more likely to recognize the occurrence of "cuesta-bridges" when he finds them, than an observer ignorant of the scheme. Astronomers and chemists have profited by searching for expected things: geographers may profit in the same way.

It must be seen now that the explanatory equipment is more ingenious than the empirical, as well as more extended. Hence the rationalistic anthropogeographer may in imagination conceive many stages in the supposed series of changes by which a given tribe has reached its present condition, without finding actual examples of all such stages in the actual

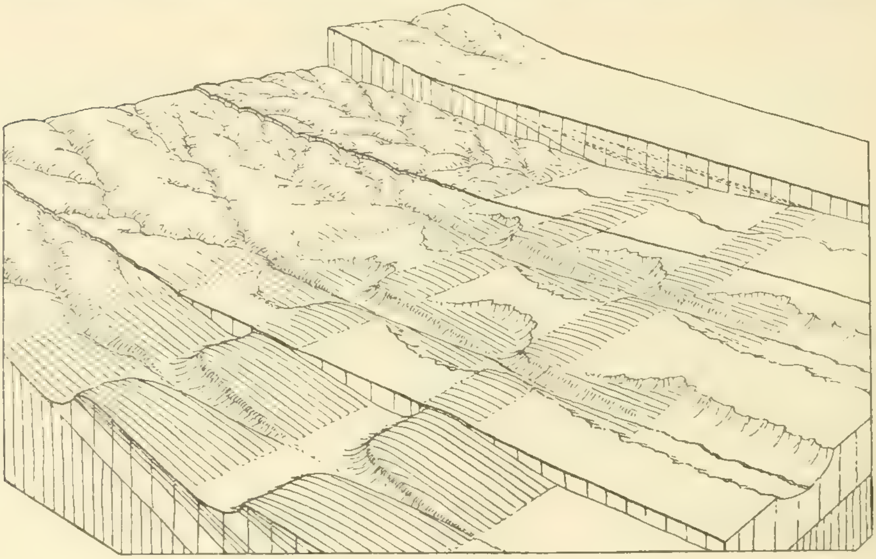

Fig. 1.—The development of cuesta-bridges.

condition of other tribes: then his description of the tribe that he is studying will naturally imply a knowledge of many stages in the supposed series of changes in tribal development as well as of related actual tribes which represent some of the stages: thus his description will involve theories as well as facts; and the more successful his theories become in restoring the unseen facts of the past, the more effort he will give to the development of a fully explanatory method of description.

Relative Definiteness of the Two Equipments.—Explanatory concepts possess the quality of definiteness in a high degree; for all explanatory concepts are formed, not as counterparts of the observable parts of actual forms, but as the counterparts of imagined forms, in which theory is combined with observation, and in which therefore the inside structure is as definitely conceived as the outside surface, and in which the past and future forms are conceived as clearly as the present form. If a consistent

empiricist attempts to describe what a rationalist would call a maturely dissected, lava-capped mesa, he must not use the word lava in the sense of a formerly molten rock, and he must be especially careful not to say anything of the inversion of topography that is associated with most mesa of this kind; he ought not, indeed, to intimate that the dark rock which he sees in the face of the mesa cliff is continued through the mesa cap, for that is a matter of inference, not of observation; and he must of course avoid all allusion to a former greater extension of the mesa and to the gradual dissection of the original surface by the slow processes of long-acting erosion, for such matters are evidently theoretical. The rationalist on the other hand, although he starts with the same facts as those seen by the empiricist, soon advances by the aid of mental processes which the consistent empiricist must never intentionally, consciously, or avowedly use, to a comprehension of the inside as well as of the outside of the mesa, to an understanding of its origin, and to a fair idea of its past and future as well as of its present form; and it is in view of all this body of fact and inference that he effectively describes the mesa in the explanatory terms above stated.

Let it not however be supposed that, if the empiricist inconsistently and unconsciously borrows some of the rationalist's helpful, inference-holding terms, he should therefore be censured. By no means; for in his case consistency is no jewel. He should be applauded for beginning to borrow and encouraged to borrow more: indeed, the surprising thing is that he borrows so little; for besides the old terms, like volcano and delta, which the empiricist already uses, there are many others just as well established which he does not use. Why does he hesitate?

Danger of Error in Explanatory Descriptions.—Perhaps he hesitates because explanatory description seems risky, and certainly it may be so if it is carelessly prepared: for a manifest danger of the explanatory method, the essence of which consists in describing seen things in terms of things unseen and inferred, is the possibility of error in the explanatory mental process by which the unseen things are "demonstrated" to be the counterparts of the things seen. It is probably in large measure because of this danger that empiricists avoid explanatory methods; but it must be also in large measure because of a certain timidity on their part that they leave to others the investigations on which explanatory descriptions are based, and hesitate to use the results of such investigations until years after their results are regarded as well assured by investigators who are familiar with them. Nevertheless the danger of error exists; it is not lessened by denying it, but rather by recognizing it, by accepting the responsibility that it entails, and by striving to guard against it.

Danger of Distraction in Explanatory Descriptions.—When proper safeguards are consciously introduced and carefully applied in a geographical investigation, the resulting explanation becomes so reasonably assured that the chief danger of the explanatory method is not the possibility

of error, but rather the probability of distraction from geographical to geological, biological, or historical considerations by the introduction of complicated and irrelevant discussions. This is particularly true of physiographic studies. Many a modern physiographic essay is so largely concerned with the analytical explanation of land forms rather than with their explanatory description, and the analytical explanation is made so unnecessarily elaborate by its extension into the remote geological past and by its employment of geographically irrelevant geological terms, that whatever geographical value the essay possesses is nearly lost from sight in the blinding abundance of non-geographical matters. The same may be true in botanical geography, if the explanatory description of the present condition of the plants of a region is introduced by so long an account of their systematic classification or of their evolutionary adaptations that the reader's attention is carried away from the geographical landscape and left in the laboratory or the herbarium. Even if a physiographic analysis or a botanical explanation is made as simple and direct as possible, it is not a desirable part of a regional description, for the delay caused by learning the proposed explanation of an object distracts the reader's attention from the object itself, and thus lessens his appreciation of the place that the object occupies in its region. This is emphatically true of many physiographic essays in which explanatory analysis of land forms is intermixed with regional description: I believe it is equally true of essays in other divisions of our science. The writer as well as the reader of such essays will be in danger of neglecting his own science for other, but further developed, sister-sciences. Furthermore, the geographical content of such an essay is not available for geographical use without searching and sifting through much irrelevant matter; and when found, it needs new statement in truly descriptive and not analytical form before it can be conveniently utilized. The geography of land forms today suffers, I am convinced, much more from distraction of this kind than from erroneous explanations; and it behooves physiographic authors to consider carefully how the larger as well as the smaller danger may be, if not wholly avoided, at least reduced to low values. But it is, as stated above, not only in physiographic chapters of regional essays that analytical explanation distracts attention from the thing described: the same is true for all the other chapters. The rational treatment of human geography, for instance, may be equally distracting if the explanatory description of the actual condition of a people is presented in the guise of a long historical account of their origin, their migrations, and their eventual adoption of their present abode; but this aspect of our problem will be considered more fully in a later section. We have here to consider in a more general manner how the dangers of error and of distraction may be practically eliminated from explanatory descriptions.

Geographical Analysis.—Safeguards against the danger of error in explanatory descriptions are found, first, in the critical conduct of the

analytical investigation that leads to an explanation, and second, in judicious care when applying an explanation. Critical analysis is a part of the responsibility of every working geographer who wishes to understand what he sees, and who therefore seeks to supplement the visible facts of the present by the invisible facts of the past, and to combine them in such a sequence as shall constitute a correct explanation of the visible facts. This is quite as true in ontographic as in physiographic problems. Furthermore, if it is desired that a critical analysis shall be set before trained geographical readers, so that they, as well as the investigator, may judge whether the analysis is safe, the investigator must transform himself into an expositor and practice artful presentation as carefully as he previously practiced scientific investigation. The presentation of a geographical analysis will, even if abbreviated, lead both writer and reader far away from the visible features of a landscape, for such a presentation exhibits the search for and discovery of an explanation, rather than its application; it may involve much geological, physical, biological, or historical study, and hence it should not be regarded as strictly geographical matter, although it may be an essential preparatory step toward making a successful regional description of the explanatory kind, as will better appear below.

The second safeguard against erroneous explanatory description is provided by the use of qualifying phrases, wherever the explanation proposed does not command the observer's full acceptance. "It appears to be . . . . ," "It seems as if . . . . ," "It looks like . . . . " serve the purpose of putting the reader on his guard, and at the same time of indicating that the explanation thus introduced represents the author's best effort to give an explanatory account of the facts that he has seen. Hence even if an explanation is not secure, it may well deserve statement, if for no other reason than that it furnishes a suggestion which other investigators may test or modify.

It should be explicitly pointed out that the object of explanatory description is not to reveal the past conditions from which present conditions have been developed, but to present the present conditions in terms of their origin: and it should further be emphasized that the only reason for adopting the explanatory method of description is that it is more powerful than the empirical method. But it is evident that an analytical investigation, which is largely concerned with past processes, does not constitute a good description: analyses must be systematized and the systematized results must be made familiar before they can properly be used in description. Thus in the study of land forms, the object of physiographic analysis is not simply to discover the past action of certain processes by which existing forms have been produced, for the study of the past as such belongs to geology; nor is it simply to understand that the existing forms are the product of past processes, for such understanding might not be conceived or phrased in such a manner as to constitute good description. The chief object of physiographic analysis is to provide a safe

explanatory theory with respect to the origin of certain observed features, so that the imagined counterparts of the observed features and of many related features may be systematically deduced from the theory, and so that these deduced counterparts may be used, whenever needed, in describing the actual features which correspond to them: in other words, the chief object of physiographic analysis is to increase the number of terms in that part of a geographer's explanatory mental equipment which deals with physical features. When this important principle is recognized, it will be seen that both the methods and the results of physiographic analysis should be systematized as far as is reasonable, in order that they may more readily serve the important practical purpose of increasing the mental equipment in a well-ordered manner; for only after such systematization has been accomplished are the results of analysis ready for immediate use in regional description. This is equally true in all branches of geography. When a climatologist states the atmospheric conditions of Chile as part of a regional description of that country, he must not stop to explain the cause of summer drought and winter rains; he must assume that his explanatory account of these seasonal features is understood, by his readers as well as by himself, from previous analytical and systematic study. When an ecologist gives an account of the flora of the Mississippi flood plain as part of a regional description of that great valley floor, he must not delay by explaining how and why the distribution of plants varies on a flood plain; he must assume that such matters are known from previous analytical and systematic study, and that the knowledge thus gained has been systematized for practical use in regional description. Let us see how this principle is carried out in the study of land forms.

Physiographic Scheme of Structure, Process, and Stage.—As the result of many successful analyses, a certain number of geographers of the explanatory school attempt to state the result of analytical study of land forms according to some orderly plan of treatment. Thus Passarge of Hamburg has proposed a scheme under the title of "Physiologische Morphologie," in which he elaborates a method of genetic classification for land forms;[1] he presents a classification under Typus, Klasse, Ordnung, Familie, Gattung, and Spezialformen, with a large number of the last subdivision, such as Abgesunkene Schollen, Treppenbrüche, Kesselbrüche, Grabenbrüche; Schlammströme, Steinströme, Bergstürze; Grund-, End-, Seitenmoränen, etc.; and under "ideale monodynamische Landschaftsformen," similarly subdivided, he includes various "Oberflächenformen," such as symmetrische, asymmetrische Kettengebirge, Rostgebirge, Kettengebirgshochländer; Hügelländer, Landschwellen, wellige Ebenen in Tiefländern, Tiefland- und Hochlandbecken. More recently Falconer of Glasgow has presented a discussion of "Land Forms and Landscapes"

[1] *Mitt. Geogr. Ges. Hamburg*, XXVI (1912), 133–337.

based on endogenetic and exogenetic processes,[1] in which he classifies over 60 specific forms under various orders, families, genera, and subgenera. So far as I have seen, these schemes have not yet been put to use in the description of actual landscapes or regions, although such a test of their practical value is evidently desirable.

The scheme that I have come to prefer for my own use, after some years of experiment upon it, takes account of the attitude and internal structure of the land mass concerned, of the destructive processes that have worked to carve or erode it, and of the stage reached in the carving or erosion expressed in relation to the long series of stages that make up a completed cycle of erosion, from the form of initial uplift to the form of ultimate degradation.[2] This scheme therefore bears a close resemblance to the scheme proposed by Hettner of Heidelberg,[3] which also has to do with three prime factors: "1. Mit den Tatsachen des inneren Baus, 2. mit den Vorgängen der Umbildung, 3. mit den durch die Einwirkung dieser auf jene sich ergebenden Oberflächenformen und Bodenarten." I have fallen into the habit of briefly stating these three prime factors as "structure, process, and stage" ("stage" being preferable to "time," earlier used), and find them essential in any thorough treatment of land forms. If two other factors are added, namely, relief of surface or local measure of vertical inequality, and texture of dissection or spacing of stream lines, the scheme thus completed becomes fivefold; but the three factors first named suffice as a handy name for it—except for those hurried students who think that they can themselves expand the name of a scheme into its full meaning; and for them even a fivefold name would be insufficient. Any elaborate and adaptable scheme, such as this one, cannot be fully understood until it has been carefully studied and practically applied. It is not my purpose to explain the scheme of structure, process, and stage in these pages; that has been done elsewhere, most completely in *Die erklärende Beschreibung der Landformen* (Teubner, Leipzig, 1912), a volume embodying the lectures that I gave as visiting professor at the University of Berlin in 1908–9; my intention here is merely to set forth certain characteristics of the scheme.

The first and most important characteristic is, that by assigning the proper values to the variable elements of the scheme, they will combine so as to produce the counterpart of an actual land form: the determination of the proper values being the work of analysis. Thus the scheme enables those who use it to give intelligible account of physiographic features in terms of their origin. The next and hardly less important characteristic

[1] *Scot. Geogr. Mag.*, XXXI (1915), 57–71, 143–51, 169–80, 244–53, 393–406.

[2] "Geographic Classification, Illustrated by a Study of Plains, Plateaus and their Derivatives," *Proc. A.A.A.S.*, XXXIII (1885), 428–32; "The Geographical Cycle," *Geogr. Journ.*, XIV (1899), 481–504; *Verh. VII. Internat. Geogr. Kongr.*, II (1900), 221–31; "Complications of the Geographical Cycle," *Proc. VIII. Internat. Geogr. Congr.*, (1905), 150–63.

[3] "Die Terminologie der Oberflächenformen," *Geogr. Zeitschr.*, XVII (1911), 135–44 (see p. 143).

is, that, by playing reasonable variations on the assigned values of the several elements, the counterparts of a great variety of related land forms can be brought to mind. Thus the scheme enables those who use it greatly to extend their mental outfit, in so far as land forms are concerned. Both of these characteristics will now be considered in greater detail.

Elasticity of the Scheme of Structure, Process, and Stage.—Some geographers seem to have conceived the scheme of structure, process, and stage as a rigid, Procrustean device, to which the facts of nature must be fitted. Is it necessary to explain away so absurd a misunderstanding? The first, brief, introductory statement of this or of any other scheme may appear to the beginner too simple and too rigid for practical use in the treatment of complicated problems; but when the scheme is followed further its easy adaptation to divers conditions soon becomes apparent. There is not an element of the scheme that is not so elastic but that it can be adapted to any complications of natural occurrences, if so complete an adaptation is desired; thus a great variety of land forms may be effectively described in terms of "structure, process, stage, relief, and texture"; but as a matter of practical use it is generally no more necessary or desirable to include all the complications of nature in a geographical scheme than in a geographical map. Like the law, geography must disregard many small things, because it has to deal with so many large things. This principle is particularly true regarding complications of past occurrence which have no effect on the geographical present: they must of course be included in a detailed geological history of their region, but they must be excluded from geographical descriptions, because they are geographically irrelevant and distracting. It is, as we shall see later, particularly important to exclude minor details from the concise introductory statement with which a good regional description should open, and here the scheme of structure, process, and stage is especially helpful; for what is wanted in such a statement is an effective summary in which the main features of the region concerned shall be clearly and simply set forth, free from distracting incumbrances, but on which all desired details can be afterward embroidered. Although the scheme of structure, process, and stage is primarily adapted to the description of land forms, it provides also an effective means of treating such related features as streams, lakes, and glaciers, for these water forms and ice forms are intimately associated with the land forms on which they occur.

When it comes to details they also can be easily represented in terms of the scheme, for every element of structure, every kind of process, and every phase of stage can be elaborated as far as need be. Instead of then having to do only with large structural masses, many of the smaller variations of structure may be taken into consideration; but it is not geographically worth while to take account of the smallest variations of structure. Again, instead of imagining the unbroken sequence of a cycle of erosion, account may be taken of as many interrupting movements

and deformations as the case demands; but it is not geographically worth while to take account of every trifling seismic displacement. Furthermore, instead of assuming the continuous action of a single process of erosion, every variation from normal to arid or to glacial process that geological investigation discloses may be given due place; but the effects of short-period climatic variations on land forms need not be discussed. Is it necessary to state matters that are so manifest as these? It would not be supposed so, had not certain critics of the scheme contrived to misunderstand it on all these points. All details can certainly be treated in this way, if desired; but in my own opinion, the other side of the problem today needs more emphasis; namely, the simplification of regional descriptions by excluding the many irrelevant geological complications that too often incumber them; and it is because the scheme of structure, process, and stage is so serviceable in this direction that it—whether under this name or not matters little—has come so generally into use among modern geographers of the rationalistic school.

One of the complications of nature which most frequently calls for departure from the simplest form of the systematic scheme concerns the variations of resistance to weathering in the different parts of a land mass. When a land mass has not a homogeneous structure, it is necessary to recognize that the areas of weaker rocks run rapidly through their cycle of erosional development and reach a mature or old stage while the resistant parts are still in a young stage of their evolution. This is nothing more than a conventional, verbal expression of the facts of the case, and yet curiously enough it has been made the ground of objection to the scheme. The objection should really be directed against the complication of the facts; but as the facts insist on being complicated, a scheme that fits them cannot remain simple.

Objections to the Scheme of Structure, Process, and Stage.— Some geographers who have themselves made little use of the scheme here under consideration object that its application in a new field demands long and elaborate geological investigation, and hence that it cannot be employed in rapid explorations of little known regions, where an empirical method must be adopted instead. It has never seemed to me wise to object to a scheme of description because its application demanded a knowledge of the subject treated. Mineralogists assuredly do not abandon the scheme of description based on composition and crystallization, because it cannot be applied to minerals that are imperfectly known; neither do botanists abandon the current scheme of the classification of plants because a plant that is passed by hurriedly cannot be identified. A mineralogist or a botanist may make a rough try at describing a specimen that he has seen briefly or imperfectly, but he does not stop there: he completes his observation as soon as possible, and is discontent until he completes it. Geographers might well do likewise: that is, use any empirical terms that serve their needs in the description of landscapes

which are imperfectly understood because of brief opportunity for observation, and return as soon as possible to complete at leisure their hurried and imperfect work.

But there is another aspect to this question: it is chiefly those who are uninformed regarding the scheme of explanatory description here considered, and who have therefore made little or no practical application of it, who regard it as useless in rapid exploration. Those who are giving serious and careful study to the scheme have often had occasion to reach the opposite conclusion; namely, that the scheme is surprisingly helpful in rapid exploration, partly because it leads the observer so promptly to take note of the significant elements of the landscape, partly because the rational treatment of land forms is often a relatively simple matter. And it may be confidently urged that the more extended the experience of the observer in explanatory description and the more elaborate his mental equipment, the more generally will he be able to make useful application of his method in giving account of any region, however rapidly he traverses it.

It is, however, again objected that, just because the most successful application of an explanatory method in the description of landscapes demands an elaborate mental equipment and an extended experience, it is therefore unsuitable for use by beginners and uninformed explorers. Of course it is! So is the thorough-going description of plants or of minerals unsuitable for uninformed persons, but that does not lead botanists or mineralogists to devise superficial empirical methods of description. The real difficulty here is that, unlike botany and mineralogy and various other well-developed sciences in which technical knowledge is assumed as a prerequisite for exploration and authorship, geography is supposed to be an open field for any traveler, whether he has had technical preparation or not. By all means let the untrained traveler continue to record his "impressions," and to publish them if he wishes; but let us avoid the mistake of thinking that, because he cannot employ a systematic explanatory method in the description of the landscapes that he enjoys, such a method is not therefore helpful to professional geographers.

Three-Phase Statement of Two-Cycle Forms.—If two cycles of erosion are found to have been concerned in the development of a certain district, the problem of describing it becomes more complicated, but the essential elements of the descriptive method are not changed. A three-phase statement then becomes helpful. The forms that were developed in the first cycle of erosion should be announced first; then the nature of movement by which the first cycle was interrupted and the second cycle introduced should be stated; and finally the forms developed in the second cycle should be specified. Simple and helpful as this orderly method of presentation is, it is often neglected. A bay may be described as the result of a movement of depression, whereby a valley was partly submerged: this is already helpful in conceiving the appearance of the bay,

but it would be still more helpful if the form of the valley before submergence, the extent of submergence, and the changes since submergence were all briefly but explicitly announced. An escarpment is sometimes described as due to a fault: that is a good thing to know, because it aids in visualizing the escarpment, but the escarpment could be much better visualized if the pre-faulting forms, the amount of faulting, and the post-faulting changes were specified. An inland bluff is sometimes interpreted as an uplifted sea cliff, and even that is a serviceable inferential statement; but the value of the bluff as a physiographic element would be more clearly indicated if the stage of its pre-uplift development, the amount of uplift, and the measure of post-uplift changes were all clearly set forth. In all these examples, the first of the three terms itself needs systematic explanatory description; for all derivative forms, such as valleys, fault scarps, and sea cliffs, should be presented in terms of the scheme of structure, process, and stage, with supplements where necessary concerning relief and texture: after that, the second and third terms are easily added.

If, instead of a change of attitude due to uplift or depression, there has been a change of climate which involves a change of process, the threefold form of statement is again advisable. Thus in describing a formerly glaciated mountain, it is desirable to indicate, first, the preglacial form of the mountain; second, the changes due to glaciation; and third, the postglacial changes: or in describing the slopes of a formerly lake-filled basin, it is desirable to state, first, the form of the slopes before the lake rose upon them; second, the changes due to the presence of the lake; and third, the changes since the lake disappeared.

Be it noted, however, that in these examples of explanatory regional descriptions as in all others, the explanation ought to be familiarized and systematically extended before it is applied. In the first case of the bay due to depression, the whole scheme of the initial production of embayments by the submergence of various kinds of land surfaces to various depths, as well as the sequential modification of the new shore lines thus initiated by the work of sea and land agencies with respect to the new baselevel, must be made familiar by systematic exercises before the scheme can properly be used in describing an actual bay. We thus come to the consideration of the manner in which systematic treatment of the results of analysis may lessen the distraction that is caused by the analysis itself.

Systematic Arrangement of the Results of Analysis.—The analytical explanation of a landscape, even if phrased as simply as possible, may, as has already been intimated, distract the attention of a reader from the present facts to their past origin, and to that extent the explanation fails of having a truly geographical quality; for a geographical statement ought surely to leave its reader vividly impressed with existing facts, whatever means are taken to produce this impression. The distraction caused by analytical explanations increases with their complication and

their novelty; hence some means must be found of making them simple and familiar. This is best accomplished by a process that may be called systematization. It consists, first, in enlarging and generalizing the explanation, so that instead of being directed immediately to the facts in hand it shall cover all related facts; second, in deducing from the generalized explanation a full series of ideal or type examples; third, in arranging the ideal examples in systematic order from the initial to the ultimate stage, whereby they may all become familiarly understood; and fourth, in giving appropriate names to certain selected members of the type series, so that they may be easily called to mind. If drawings of the named members of the type series are added to supplement their verbal description, so much the better. When all this has been done, the mere name of any member of the series will recall it and the explanation that goes with it; the name can then be used in explanatory description with a minimum of distraction.

Let it be understood that the type forms thus established in a systematic series are not empirical imitations of actual land forms; they are imagined examples of rationally developed land forms, deduced from a general explanation, the validity of which has been previously established by a critical analysis; and herein lies their chief advantage. For if they were merely empirical examples, their inner structure and their past and future stages would be unknown; while as rationally developed forms they are transparent in space and time, they are known through and through, in the past and the future, and all the members of a series are helpfully related to one another. Moreover their elements are not arbitrarily combined, as must be the case in all purely empirical concepts, but reasonably and genetically associated. The separate elements will therefore be easily remembered under the name of the whole which suggests them. Although systematic methods are familiar in many branches of science, and although they are applied to geographical problems to a certain extent in many textbooks of geography, the application is too often empirical in its nature; or if explanatory, it is incomplete. I believe that great progress is yet to be made in the mature and disciplinary training of geographers by the more extended use of thoroughgoing systematic methods of the explanatory kind in all branches of geography. In order to lend more emphasis to this belief, the two following sections give more explicit illustration of the principles on which it is based. We shall first consider the application of explanatory analysis to a single landscape, and then consider the enlargement of the results gained by subjecting them to extension by systematization.

Ridges, Cuestas, and Benches.—Imagine an observer at the point C, Fig. 2. If he be a consistent empiricist, he will note the trend and height of the lopsided ridge on which he stands, its steeper slope to the northwest, its gentler slope to the southeast, its interruption by a transverse valley; also the appearance of a rock face, which is more or less continuously

exposed in a nearly horizontal belt along the top of the steeper slope and in oblique belts along the edge of the descending walls that inclose the transverse valley. But as a consistent empiricist he will have no right to describe the ridge as of monoclinal structure, for he sees only the surface, not the inner mass; he cannot make the step from direct observation of the surface to theoretical inference as to the interior structure without the use of various other faculties than observation and generalization. To be sure, this step is familiar and safe, and few observers would today hesitate to make it; but it is nevertheless a step from observation to inference, and hence a step from the empirical toward the explanatory method of description. It is truly an excellent step to take; and there are today not only no rationalists but probably no empiricists who hesitate to take

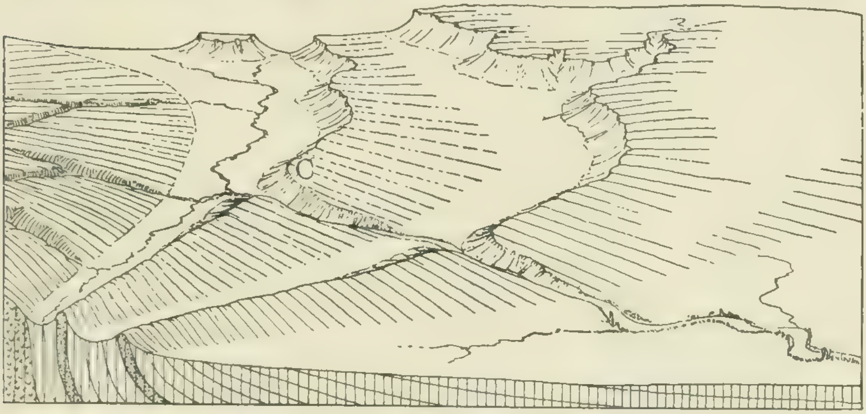

FIG. 2.—The relation of cuestas to ridges and benches

it; but the wonder here is that those who thus overstep the boundary of direct observation in this element of the problem do not similarly overstep it all along the line of geographical adventure, and thus, consciously forsaking the limitations of the empirical method, avow themselves to be rationalists.

Again, the consistent empiricist should not describe the transverse valley as having been eroded through the ridge; for to him the valley is not the product of the past processes: it simply exists. It has in his system of geography the place that a large tree has in the philosophy of certain American Indians, who insist that, although grass grows, big trees were created in their present size. The consistent empiricist has no right to make use of the unseen processes of inferred past time, for he has no observational knowledge of the past. He ought to regard all actions of unseen, past processes as unsafe elements in geographical descriptions; yet few empiricists today have so fully the courage of their opinions as to avoid speaking of a valley as the result of unobserved erosion in assumed past time; for they, like everyone else, are fully persuaded of the reason-

ableness and verity of such a process, in spite of its proof being based upon unproved and unprovable postulates—members of a great body of assumptions which are essential in all scientific investigations, and which are pragmatically accepted because they "work" so wonderfully well. Here again the marvel is not at all that the empiricist inconsistently steps over from the narrowly inclosed path of direct observation to the broader road of rational inference when he has to do with a simple valley; the marvel is that he thinks it possible and profitable in this modern day to try to remain an empiricist in the rest of his work.

The rationalist has more fully the courage of his avowed opinions. He finds so much inspiration in the results already reached by geographical analysis that he is resolved to apply the principles upon which those results are based to all the rest of his problems, even to problems which have until now not yielded to explanatory description. And so different is this spirit of endeavor from the mistrust of the empiricist that, on learning that "rationalists have the courage of their opinions," he shakes his head and exclaims: "This is sad but true"; as if the future progress of geography would be endangered by continuing the kind of work that has brought our science to its present stage of advance.

If a rationalist studies a landscape such as that pictured in Fig. 2, he calls to mind the abundant evidence provided by geological science to the effect that the strata which outcrop along the scarp of the lopsided ridge, as well as the weaker under- and overlying strata, once extended obliquely northwestward up into the air, just as they still dip obliquely southeastward down into the earth, although both extensions are matters of inference, not of observation; he thus comes to understand that slow and long-acting processes of erosion have already consumed the former upward extension of the strata, as they will in the future consume a part of the downward extension; that the stream which flows through the transverse valley is responsible for the notch in the ridge; and so on. Thus he comes to feel reasonably assured that his explanatory inferences as to the origin of the existing features are correct; not that he is absolutely sure he is right, for he will do well to leave the discussion of absolute belief to metaphysicians, whose delight it is to concern themselves with such-like unpractical matters; but that he is reasonably satisfied he is right, and therefore announces his explanatory inferences on the usual pragmatical ground that they satisfy all the cases that have come to his knowledge. If new cases come up later and demand a revision of his inferences, he will revise them willingly and profitably; but in the meantime he proposes to use them as they stand, because he has reasonably satisfied himself that it is reasonable to do so.

Now he can proceed to the systematization of his results. For this purpose he studies out the earlier and the later stages in the progress of the destructive processes working on the given structural mass, by which the existing forms have been produced; he examines the factors which

determine the form before him, and then deduces the variations in form that must result from variations in the value of the controlling factors: the crest may be high or low, according to the initial altitude of the dissected mass, its distance from the ocean to which its rivers flow, the climate in which it has been developed, the resistance of its rocks, and above all according to the stage in the cycle of erosion that it is undergoing; the crest may be arched or even, according to its development in one or in two cycles of erosion, and to the stages reached in each cycle; it may be direct or irregular, narrow or broad, according to the dip and thickness of the determining strata; and it may be simple or compound according to the absence or presence of interbedded weaker strata; the steeper slope or inface may be of simple or compound descent, with few or many, shallow or deep obsequent ravines; the back slope may be longer or shorter according to the dip of the strata, and of continuous descent or broken by subordinate ridges according to the composition of the strata; and the back slope may have many or few, shallow or deep, consequent (or resequent) valleys; the transverse valley of the master consequent river may be

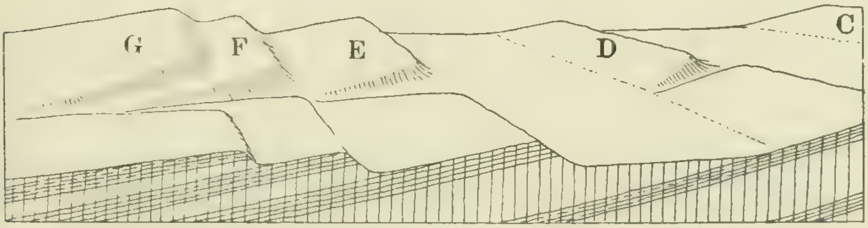

FIG. 3.—Open-spaced, close-set, and overlapping cuestas

joined by short or long subsequent streams from the tributary subsequent valleys; and all these features may be treated in such further detail as the nature of the problem demands.

The rationalist may of course make mistakes in deducing the consequences of all these varying factors, but he tries to avoid mistakes by comparing inferences here with observations elsewhere, and by thorough discussion submitted to public criticism. He takes care to consider the reasonably possible variations in the attitude and composition of the determining strata, and sees that, with increase of dip to vertical, the broad, lopsided ridges in the middle of Fig. 2 will become narrow symmetrical ridges, as in the foreground; or with decrease of dip to horizontal, they may pass into plateau benches, as in the background: a beautiful illustration of such change is found in the passage of a steep-sided Appalachian ridge northeastward into the Pocono Plateau of northeastern Pennsylvania. He sees that, according to the relative thickness of the weak and strong strata, the adjoining lopsided ridges may be arranged in wide-spaced order, as *C*, *D*, *E*, Fig. 3, between which the subsequent valleys are broad-floored lowlands; or in close-set order, as *E*, *F*, between

which the subsequent valley, although narrowly limited by the back slope of one and the inface of the next ridge, is still worn almost as deep as the main consequent valley; or in overlapping order, as *F*, *G*, in which case the subsequent valley between the two crests stands, for the most part, at a distinctly higher level than the floor of the consequent valley that traverses them. Thus he rapidly reviews the whole range of variations on his simple original theme, and thereby not only enlarges his equipment of ideal forms, some of which may sooner or later prove to be the counterparts of actual forms, but also gains a fuller appreciation of the actual forms which have prompted his analytical and systematic studies.

If he thinks his problem is novel he publishes the analysis by which he has reached its explanation, and adds to the analysis a moderate number of the more important ideal type forms that he has systematically deduced from his general explanatory theory under the action of destructive processes on the varying structures through one or more cycles of erosion; he suggests some terms by which the deduced types can be conveniently named, and he adduces some actual examples of the deduced types from other districts; then he leaves the analysis and the systematic terms to be adopted or discarded, as his colleagues see fit. The provisional phrase, lopsided ridge, for the forms shown in Figs. 2 and 3 may not satisfy him, and in its place he may prefer the Spanish word, cuesta, introduced into English by Hill, as a name for the form that is intermediate between a ridge proper with steep slopes on both sides, and a bench in which a flat surface falls off in a cliff. To be sure the word, cuesta, means in Spanish any sort of a hill, and not only a lopsided ridge; but likewise the Spanish word, ria, introduced into German usage by Richthofen, and now widely adopted, means any broad or estuarine river mouth, and not necessarily an embayment produced by the partial submergence of an open valley in a mountainous coast, in the sense that Richthofen originally proposed. Yet ria is now very generally used in a restricted and explanatory meaning, even in so geographically conservative a country as Great Britain; hence cuesta may also come into use with equally good reason, although at present lopsided ridges are often called escarpments by British geographers, who thus name the whole by one of its parts and leave the reader in some uncertainty as to whether the part or the whole is meant. But let no one imagine that any special value inheres in the terms, "cuesta," "wide-spaced," "close-set," "overlapping," "subsequent," and so on, that have been used in this paragraph, for other terms would do just as well, provided they are generally enough accepted to call attention to the facts. The recognition of the facts is the really important matter.

After an observer has enlarged his mental equipment regarding forms of monoclinal structure by the systematic expansion of the results of analysis in the manner indicated above, he will not only be much better able to describe all such forms accurately and intelligently than he was before, but he will also be much aided in searching out and noting down the critical

facts regarding such forms while in the field, for observation is immensely aided by pertinent knowledge. The same is true regarding the forms developed by any kind of process on any kind of structure. And yet the empiricists sometimes object that it is dangerous thus to use theory as an aid in observation! I cannot believe that so timid an opinion is founded on earnest and studious experience; for although it is of course true that a poorly trained, undisciplined observer may be misled by an over-confident belief in the results of theoretical explanations which he has learned rather on the authority of someone else than on the ground of his own critical analysis, it is also true that a well-trained, disciplined observer will consciously and carefully guard himself from so elementary a mistake as thinking that he sees a non-existent feature; and he will be successful in so many cases that he is warranted in running the risk of error in exceptional cases, if such arise. A well-developed, systematic, explanatory understanding of land forms gives aid in field work because it leads the observer to note precisely such points as are most critical in determining the nature of the forms before him. The timorous, untrained geographer thinks that such aid will mislead him to see non-existent things that he expects to see; the more enterprising and better trained geographer knows that such aid will lead him in the most direct way to see whether certain expectable things exist or not.

A Meandering Valley across Overlapping Cuestas.—One of the best instances I have noted of the practical value that follows from the systematic extension of an analytical explanation concerns a meandering valley—that of the Armançon, a branch of the Seine System—which crosses several overlapping cuestas in the southeastern part of the Paris Basin. My first acquaintance with the beautiful landscapes of that district was during the "Geographical Pilgrimage from Ireland to Italy" in 1911, of which a brief account has been given in these *Annals*.[1] The valley then proved so interesting that return to it was made on an inter-university geographical excursion from Paris in the spring of 1912, the results of which are briefly set forth in the *Annales de Géographie* for that year. The district consists of alternating stronger and weaker strata, gently inclined to the northwest, and shows the remains of an uplifted peneplain, *AB*, Fig. 4, which obliquely bevels the stronger cuesta-making strata, and in which a meandering transverse valley, *CF*, is maturely incised; but it is significant that, where the valley floor, *EF*, is occupied by the weaker strata, it is already widened to a late-mature expression in which all trace of its earlier meandering stage is lost, and that only where the stronger cuesta-making strata gradually descend to river level, as at *DE*, is the meandering valley pattern still preserved: it is also significant that, as one advances downstream, the valley floor gradually changes from its wide (*D*) to its narrow (*E*) measure, and then suddenly changes from its narrow to its wide measure. It is by the discovery of

[1] II (1913), 73–100.

detailed features of this kind, which may very likely be recognized by observation before they are consciously deduced in the systematic expansion of a pertinent analysis, that one confirms the correctness of the analysis. It is by the systematic treatment of all such detailed features that the physiographer best extends his own equipment for future observation; and it is in the systematized form that such details are best published for the use of any others who may care to employ them. These details of the valley of the Armançon are not mentioned here because they are of empire-making importance, for they are not; nor because they are difficult to understand, for they are simple enough when attention is directed to them; they are mentioned because they illustrate so well the value of the systematic expansion of an analytical explanation in the treatment of an attractive landscape.

For be it noted that the words, "already" and "still," in the foregoing description imply a knowledge of other stages in the development of an incised meandering valley across overlapping cuestas; hence the description can be fully appreciated only after a systematic extension of the

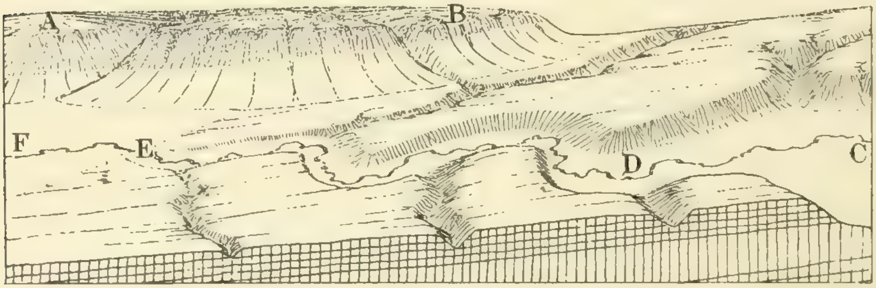

Fig. 4.—A transverse meandering valley in overlapping cuestas

problem through its earlier and later stages. That extension is not here presented; but it should be consciously carried out, verbally and graphically, by anyone who wishes to obtain full familiarity with forms of the kind here figured, preparatory to the easy use of their names in regional description. After such familiarity has been gained, the descriptive phrase, "a meandering valley across overlapping cuestas," will contain a large amount of pertinent and helpful meaning. It may be mentioned in passing that the sudden widening of the valley floor, as the stream advances from the vanishing back slope of a cuesta-maker into the next intermediate weak stratum, as at *E*, Fig. 2, suffices to prove that the widening of that part of the valley is not due to the lateral oscillation of its meandering stream, but to the lateral retreat of the next overlying cuesta-maker where it is sapped by the intermediate weak strata.

Some geographers, whose interests lead them to discuss world-wide problems, care little for details of the kind here considered; others, who enjoy the contemplation and description of visible landscapes, find every

detail worthy of attention. Surely no adequate account of the valley of the Armançon and of many similar valleys in the eastern part of the Paris Basin can be given without recognizing their systematic alternation from lesser to greater width; and without such an account no clear appreciation of village sites and of local industries can be gained. In the valley of the Armançon, for example, the location of villages and of many large quarries can be very concisely expressed in terms of the valley forms; not that these villages and quarries are of world-wide importance, but that they are essential to the true description of the district concerned. Similarly, no proper understanding can be reached of the different lengths of four lines of transportation that follow the Armançon Valley unless the detailed form of the valley is clearly apprehended: the highway can hold a nearly direct course over the lower part of the gently sloping back of a cuesta between two open valley-floor stretches, and is therefore the shortest of the four lines; the railway cannot rise so high above the river level and hence must follow for the most part the larger valley curves, although it here and there cuts through a low cuesta spur or tunnels through a higher one; the canal must follow all the meanders of the valley floor, but it does so in smooth curves with long tangents; the Armançon, being a typical example of an underfit river, embroiders many small meanders on the larger meanders of the incised valley, and continues its small-curve pattern through the open valley-floor stretches where the other three lines follow nearly rectilinear paths; hence the river course is much longer than the canal, the canal is longer than the railway, and the railway is longer than the highway. It may be noted here that the Armançon was one of the French rivers to which Dr. Lehmann, who was a member of the inter-university excursion above referred to, applied his explanation of underfit streams, of which some account has been given in a recent volume of these *Annals*.[1]

Graphic Aid in Systematic Study.—If the two preceding sections were read aloud to a hearer who did not see the accompanying diagrams, he would have some difficulty in understanding what is meant by overlapping, close-set, and wide-spaced cuestas, or by the gradual narrowing and the sudden widening of a meandering valley floor through overlapping cuestas, especially if his experience in the study of land forms has not been large. If either section be read to him a second time, while he looks at its diagram, his difficulty will probably disappear. The practical lesson of such an experiment is that the verbal description of type forms ought to be accompanied by appropriate figures in geography as well as in paleontology. Block diagrams in series, showing successive stages in the erosion of a single structure, are to be particularly commended in systematic presentation. If graphic devices of this kind are accompanied by a careful verbal statement of the essential elements which make up the type form in each stage of its erosional evolution, and by appropriate

[1] III (1914), 3–28.

names for the forms in the more important stages of their evolution, a valuable contribution to mental geographical equipment will be made; for the equipment will then be definite on the side of the writer and intelligible on the side of the reader.

It need hardly be pointed out, after what has been said above, that the block diagrams here recommended are not intended to represent actual forms; for they avowedly represent ideal, imaginary forms: nevertheless, the mental concepts thus presented by the writer and acquired by the reader, together with the names by which they can readily be brought to mind, supply the best means of describing the actual forms of which they are the counterparts, and therein lies their value. They are practical helps in showing the results of geographical exploration when it comes to preparing geographical descriptions.

The Value of Technical Terms.—The value of explanatory technical terms, such as delta, volcano, cuesta, monadnock, moraine, ria, and so on, in geographical description does not lie only in the avoidance of cumbersome paraphrases, but also in the avoidance of geological distraction—provided that the introduction of the terms has been preceded by the explanation of the forms that they name, warranted by competent analysis and familiarized by careful systematization. Of course, a series of terms such as consequent, subsequent, obsequent, insequent, and resequent will seem difficult to anyone—a geologist, for example—who without interest or patience enough to study the things that the terms conveniently name tries to make a hurried etymological attack on physiographic problems; but to those who learn such terms as names for things, just as a mineralogist learns orthoclase, plagioclase, periclase, and loxoclase, or as a botanist learns glossopteris, dryopteris, goniopteris, actiniopteris, arthropteris, and hecistopteris, they will present no serious difficulty.

So long as physiographic descriptions contain elaborate explanations and cumbersome paraphrases, in which the action of process on structure in past time is the leading idea, it is difficult for the reader to hold his attention upon the geographical present. But if all the considerations which involve past time have been previously analyzed and systematized, and if the resulting concepts of land forms, thus made clear and familiar, have been graphically represented and technically named, the mere use of a name will suffice to bring forward the intended concept; and thus distraction by geological considerations will be reduced to its lowest terms. In illustration of this statement I take the liberty of referring to two of my articles,[1] in which the use of the term morvan serves in large measure to exclude geological distraction from a geographical description, where such distraction would otherwise be an embarrassment. It is

[1] "Relation of Geography to Geology," *Bull. Geol. Soc. Amer.*, XXIII (1912), 93–124 (see pp. 112–18); "A Geographical Pilgrimage from Ireland to Italy," *Ann. Assoc. Amer. Geogr.*, II (1913), 73–100 (see pp. 89–92).

perhaps wise to state at the same time that a recent writer[1] has condemned the term morvan, on the ground that different morvans are very unlike; but I may also state that this writer is a historical geographer who has made little use of modernized physiography; that he has not made practical trial of the value of morvan by using it and its long, paraphrased equivalent in rival descriptions; and that although he rejects the new term, morvan, he accepts the old term, volcano, in spite of the greatly diverse forms that it names. My own belief is that he rejects morvan because it is new and unfamiliar. In spite of its novelty morvan will probably be adopted by those who are thoroughly familiar with the well-defined group of features thus named and with the explanation of their origin, so that they can use the term with an easy mind; and who at the same time have so frequent need of thinking, writing, or talking about the grouped features, that they must use either a term or a paraphrase. Those who have no such occasion to use the term, or who feel uncertain as to the validity of its explanatory content, will probably condemn it on abstract grounds, without ever making a practical trial to ascertain its value.

It is however desirable that technical terms should be as simple as possible; it does not appear necessary to go so far as Falconer, who says: "A moraine landscape much dissected by stream and run-off is . . . . to be classified not as an exogenetic aggradation landscape, but preferably as an exogenetic degradation landscape"; and it is surprising that so pronounced a Germanist as Passarge, who, although he uses Vulkan, Lakkolith, Kame, Drumlin, Delta, and Atoll, objects to other foreign terms, such as Cuesta, Bolson, and Playa in German books, saying: "Wer deutsche Werke lesen will, muss eben deutsch lernen," should employ such complex exotic phrases as "Monodynamische und polydynamische Einzelformen," and "Das Studium physiologisch-morphologischer Karten," in which only *und*, *einzel*, and *das* are "deutsch." Löwl's elaborate terms, *Symptygmatisch*, *anarregmatisch*, *heteroptygmatisch*, *bikataklastisch*, and *pseudotektonisch*, for the description of valleys[2] have not, I believe, come into use even among professional geographers.

Use of Verbs in the Present Tense.—Another expedient for the lessening of geological distraction in physiographic descriptions may be noted. Inasmuch as geography is particularly concerned with the existing features of the earth, the use of the present tense in geographical descriptions is to be recommended. Experiment will show that the distraction caused by over-emphasis of past geological processes in explanatory geographical descriptions may be much lessened if the past tense, in which the action of such processes is usually stated, is avoided and if the description is rephrased and simplified so that it may announce the existing result

[1] Ricchieri, G.: "Sui Compiti attuali della Geografia come Scienza," *Riv. geogr. ital.*, XXI (1914).

[2] *Ueber Talbildung*, Prague, 1884.

of past processes in the present tense; for by this simple device weight is laid on the geographical product of past geological processes instead of on geological processes themselves. In illustration of the principle here involved, an example will first be given with a number of its verbs in the past tense, and then rephrased with its verbs in the present tense.

Past-tense description.—The Valdarno, a maturely open valley in the Apennines of Central Italy southeast of Florence, has been excavated by the Arno to a depth of 100 meters, and a width of about a kilometer for 30 kilometers through a horizontal series of Pliocene gravels, sands, and silts. These strata were deposited in an intermont basin, about 30 kilometers long by 10 or 12 wide, that was formed by the slow warping of the region in which a late-mature valley had been previously eroded between subdued ranges. Some of the basin strata were laid down with many changes of texture; hence they were probably deposited by torrential streams from the inclosing mountains, and therefore the basin was presumably filled about as fast as it was warped; but some fine silts were stratified with even bedding, as if they had been deposited in standing waters; hence local, shallow, temporary lakes may have occupied parts of the basin at times when the warping was exceptionally rapid. Many plants and animals that lived during the period of basin filling were buried and fossilized in the accumulating strata; deer were especially abundant.

As the basin was being aggraded, its surface, except when and where lakes occurred, was made up of many laterally confluent fans, which headed in the mouths of the mountain valleys and extended forward from each side of the basin toward an axial depression; there the trunk stream of the basin had its course; but as the mountains on the northeast were much higher than those on the southwest, the fans on the northeast were built up to greater height and length than those on the southwest, and hence the axial depression was displaced from a medial line toward the southwestern range. After the warping and aggrading ceased the Arno still ran along the axial depression, but it then became a degrading stream and thus eroded the present Valdarno beneath the smooth surface of imperfectly consolidated basin strata. As the Arno deepened its valley, the side streams which had been aggrading their fans degraded new valleys along whatever fan radius they happened to be following when the change from aggrading to degrading took place; and each fan has now been trenched up to its mountain-base apex. The larger lateral valleys have gained a broadly mature form; as the valley sides retreated from the stream lines, steep bluffs were maintained where cemented gravel beds outcropped, and bad-land forms were carved in some of the fine-textured silts; but most of the strata were weathered to well-graded slopes.

Present-tense description.—The Valdarno, in the Apennines of Central Italy southeast of Florence, is a maturely open valley, about 30 kilometers long, 1 kilometer wide, and 100 meters deep, eroded by the Arno through a submaturely dissected series of imperfectly consolidated, horizontal

gravels, sands, and silts that occupy an intermont warped-valley basin, measuring about 30 kilometers in length by 10 or 12 in width, between subdued mountain ranges. The even upland surface of the many interfluves between the side branches of the Arno, all standing at accordant levels, are remnants of laterally confluent fans and thus represent the formerly continuous plain of the aggraded basin. They still slope very gently from the mouth of each mountain valley toward the axial depression of the basin, beneath which the Valdarno is excavated. As the mountains on the northeast are much higher than those on the southwest, the fan remnants on the northeastern side are higher and longer than those on the southwest; hence the Valdarno lies nearer the southwestern than the northeastern range. Each side valley follows a course that still represents a radius of its fan accidentally chosen as a stream path at the time of the change from the former aggradation to the present degradation of the basin; and each fan is trenched up to its mountain-base apex. The larger lateral valleys are well matured, with graded soil-covered side slopes for the most part, but showing occasional bluffs in cemented gravels and badland forms in fine-textured silts. Fossils of plants and animals are abundant in certain strata.

The difference between these two accounts of the Valdarno is not great, but it is in the right direction. The present-tense description may be made even more concise if we assume that the features of intermont basins have already been systematically set forth, from the introductory stages of their first aggradation to the ultimate stage of the removal of all their deposits; for then it will suffice to say, in a brief statement, that the Valdarno is the fully matured axial valley, about 100 meters deep and nearly a kilometer wide, of a submaturely dissected intermont basin of unconsolidated sediments, measuring 30 by 10 or 12 kilometers, and inclosed by subdued mountains. All mention of past processes is here easily avoided, because they have been once for all dealt with in the establishment of the systematic series of deduced types which represent successive stages in the aggradational and degradational evolution of an intermont basin; each type, after it comes to be familiarly understood, can then be conceived as the possible counterpart of some actual land form, and immediately used in a regional description. The mere name or phrase by which any type is brought to mind at once carries with it a sufficient understanding of past processes by implication, and no explicit mention of them is necessary.

Students will find profitable exercise in rephrasing geological accounts of the origin of existing features into geographical accounts of the features themselves. For example, the following description with seven verbs in past tenses may be rephrased to geographical advantage with present-tense verbs: "The compound mass . . . . was long ago jostled on many crisscross faults, whereby an uneven surface was produced, the neighboring blocks were thus divided by fault-scarps . . . . then the district

was baseleveled. . . . . Later came a broad uplift without faulting, and in the cycle of erosion thus introduced many narrow fault-line valleys have been eroded . . . . in the area of the resistant crystallines, and broad lowlands have been excavated . . . . in the large patches of covering strata." In spite of their past tenses, the sentences here quoted are taken from a regional geographic description, prepared for a geographical and not for a geological journal. Their author should have taken heed of the sound geographical philosophy shown by Emerson when he apostrophized Monadnock as—

"Thou grand expressor of the present tense."

Exclusion of Irrelevant Geological Matter.—The danger of distraction by the introduction of irrelevant complications into explanatory descriptions has already been mentioned. Such distraction is nowhere more common than in physiographic descriptions in terms of structure, process, and stage; for in statements concerning structure and process the author may be tempted to introduce an excess of geological matter, which gives the printed page truly an erudite appearance, but which too often contributes nothing to the better understanding of the described landscape. During the preparation of the description it may very likely be necessary to read many geological articles in order to learn what ought to be known about the structure of the district; but it is not necessary to publish the geological information thus gained, except in so far as it is directly helpful in geographical work. It is a sound principle of geographical description to omit all geological matter, however important it may be in some other relation, if it does not aid in picturing existing features. The use, for example, of the names of geological formations, such as Carboniferous, Triassic, or Tertiary, should be avoided, because these names tell only the date in the remote past when the strata concerned were laid down; they should be replaced by phrases descriptive of composition, attitude, and appearance, such as folded resistant blue limestones; inclined hard and soft red sandstones; or weak horizontal gray clays. An exception to this rule may be made if the geological name of a formation has entered so far into scientific usage as to have a geographical as well as a chronological meaning; but such exceptions must be rare, for it can seldom happen that the names proposed by geologists or paleontologists, to suit their needs, will serve a geographer's needs so well as names that he himself proposes. In descriptions of the Valdarno, presented above, the use of the term Pliocene in the first gives no aid in picturing the landscape; hence it is omitted from the second; but the phrase, "series of imperfectly consolidated, horizontal gravels, sands, and silts," is retained, because the structure thus indicated is evidently helpful in understanding and therefore in conceiving the existing land forms. In so far as "Pliocene" might implicitly aid a geographer by indicating the relatively short subsequent time that the deposits concerned have been exposed to erosion, that aid

is much better given by the explicit statement "maturely dissected series." On the other hand, nothing is said in the present-tense description about deposition by torrents or in lakes, because all that a geographer needs to know of the deposits thus produced is implied by the announcement of beds of gravels, sands, and silts in a warped-valley, intermont basin. Whether the final sentence regarding fossils should be retained in the present-tense description is a matter of taste; but certain it is that the occurrence of fossil vertebrates has brought a good number of scientific pilgrims to the Valdarno, while the occurrence of fossilized plants in the form of lignite beds has sufficed to determine a small mining industry near the middle of the southwestern side of the basin; if the description were extended to include economic factors, such an industry would of course be mentioned.

It is only by attending scrupulously to details of this kind that a strong geographical discipline can be developed and maintained. In case an author is writing an article that is at once geographical and geological, there is naturally enough no reason for excluding geological matters; but in that case it is likely that geology, the better-developed science, will take the greater share of attention of both the writer and the reader, and geography, the less-developed science, will come in only as a poor relation, thankful to get whatever remnant of attention may be left over for it. As an example of a geographical article with an excess of geological matter in its physiographic pages, reference may be made to an account of the Macclesfield district in Central England, published in a recent number of the *Geographical Journal* of London.[1] The "physiography" of the district is by intention a history of its geological development, not a description of its present form in terms of its development. It includes discussions of the conditions of deposition of Carboniferous, Permian, and Keuper strata; it treats of the former extension of long-vanished formations over the district concerned; it elaborates the details of faults and folds; it discusses successive cycles of erosion and the glacial incident in the order of their occurrence; it is therefore a thoroughgoing study of geological evolution: and even in the closing summary it preserves a historical style from which it is very difficult to gain a clear understanding of the existing landscape. For geological evolution the essay is doubtless excellent, but as it is published as an explanatory account of land forms in the first chapter of an essay on regional geography, many readers of the conservative geographical journal in which it appears will presumably regard it as a characteristic example of a modern method of explanatory description, and will thereupon condemn such explanatory descriptions as far too geological for their geographical needs; and they will be quite right. Such a chapter must therefore work harm to the cause of rational geography.

[1] Baker, B. W.: "The Macclesfield District. I. Physiography," *Geogr. Journ.*, XLVI (1915), 117–40.

It is advantageous to omit irrelevant geological matter from regional descriptions, not only because the reader's attention will thereby be more easily held to geographical matter, but also because a short essay is more likely to receive attention than a long one. This is an age of printing; and the number of pages that a geographer must read in order to keep pace with the progress of his science is becoming burdensomely large. Any device that will reduce the number of pages without lessening their geographical content will be a benefit; and among such devices I am inclined to place a high value on the simple one of excluding irrelevant learning. In this connection, it may be permitted to advise not only the omission of irrelevant geological details, but also the exclusion of unnecessary commonplaces, such as: "The origin of this valley is closely related to the geological changes which have affected the surrounding region; and the details in the outline of the valley are dependent on local structural conditions." Mature readers do not need to be told anything so evident as that, and the space thus taken might better be left blank.

The net result of these recommendations is that regional geography will be at its best when its subject matter is presented without delay by preliminary analyses, without dilution by redundant explanations, and without distraction by irrelevant erudition. I recall with satisfaction a suggestion to this end made at one of our meetings when, a speaker having elaborated his ideas regarding the past origin of the forms in a certain mountain range, a listener asked for a description of the existing mountains. Much of our work needs the rearrangement thus suggested. The incident is recalled with none the less pleasure because the listener was one of my former students and the speaker was myself.

Serious Preparation Necessary for Regional Descriptions.— The main thesis of this paper is that good work in explanatory regional geography demands serious preparation in the explanatory analysis of many special problems and in the systematic arrangement of their results. The examples thus far presented in support of the thesis are chosen for the most part from only one division of the broad subject of geography, but it is believed that equally pertinent examples might be selected from its other divisions, for they, as well as the division of land forms, demand analytical and systematic treatment. The comment sometimes made on the foregoing thesis is that it compels a geographer to make an overlong, laborious, and roundabout approach to a subject that might be entered more directly. The answer to this comment is that those students who enter regional geography without serious training in analysis and systematization will inevitably fail to accomplish the best work. The geographical elements of a region can be clearly described only in terms of previously acquired geographical concepts of the explanatory kind, and if a geographer's equipment with such concepts is scanty and vague—as it will be if he is little trained in the analytical and systematic steps that are essential to description—his descriptions will be imperfect. It is

not a question here of preparing a course in geography for use in schools or colleges, but rather of indicating the nature of the preparation needed by one who proposes to devote himself to geography as a life-work, and who wishes to address, through his writings, others as seriously prepared as himself. The reduction of the problems of advanced geography to school grade by the omission and simplification of their more difficult and elaborate parts is educationally an important matter, but scientifically it is much less important than the study of the advanced problems; and it is to the best means of attacking and solving one of the most difficult of those problems—the accurate and intelligible description of geographical regions—that this essay is directed.

There is no "short course" by which real competence can be attained in regional geography, the most difficult and comprehensive phase of our science; just as there is no "short course" by which real competence can be attained in the study of the flora or the fauna of a region. Good work in the study of a flora or a fauna demands previous training in structural and systematic botany or zoölogy; similarly good work in regional geography demands previous training in analytical and systematic geography through all its many branches. Nothing less than disciplinary training of this kind can develop the power of critical discrimination which is necessary, first in selecting truly geographical material from among the embarrassingly abundant facts revealed by research in the field and library, and second in presenting and arranging the selected material in such form and order as shall give a vivid picture of the unsystematic groupings and arbitrary regional relations into which the many facts enter. Much good work of this kind has been done, but better work remains to be done. It must be evident that if a regional description is halted in order to introduce proof of its explanatory phrases or explanation of its terms, its regional quality will be sadly diluted. As far as land forms are concerned all such matters as the five factors involved in the fully developed scheme of structure, process, and stage must be made familiar before regional physiography is attempted; for it is in accordance with this scheme, or with some equivalent scheme, and in terms of the counterparts of possible actual examples, systematically deduced by means of the scheme, that land forms are best treated in regional description. Likewise, the three-phase statement for two-cycle forms, or some equally effective form of statement, must be already familiar as a corollary of the scheme of structure, process, and stage. Only then can good regional work proceed.

It is my strong belief that correspondingly helpful schemes must be made ready for use in the treatment of all other divisions of geography, and it is to be hoped that they will be prepared by specialists in those divisions. Some such schemes have been already presented in greater or less fulness; climatology in particular has been well systematized, usually in a more or less distinctly explanatory manner. In ontography, a scheme that has attracted me more than any other is the ecological scheme announced by

our recent president, Professor H. C. Cowles; for it includes not only the idea of "plant formations," familiar to many botanists, but the much larger idea of the adaptation of such formations to the slow changes suffered by land forms under erosional processes. The development of this scheme in form for practical application in regional description will be a great step in geographical progress; and it will involve about as many applications of analysis and systematization as are necessary in the treatment of land forms. Whether the subjects of zoögeography and of anthropogeography can be correspondingly analyzed and systematized in preparation for regional use I must leave to the determination of students in those special fields; but it is surely advisable that earnest experiment should be made in that direction: perhaps it has already been made more than I am aware.

Homologous Treatment of All Branches.—Although my own experience in geographical description has been for the most part limited to physiographic studies of land forms, I shall now venture to indicate certain principles that seem to me of importance in the treatment of ontographic problems in regional geography. The first principle is that a well prepared regional description should have the same kind of treatment in all its parts. If the account of the vegetation is brief and elementary, then the accounts of the land forms, the climate, the fauna, and the human element should be correspondingly brief and elementary. If the account of human settlements and industries is scientific and elaborate, then the accounts of land forms, climate, flora, and fauna should be correspondingly scientific and elaborate. Only by homologous treatment of all its branches can the complex subject of regional geography reach a well-ordered development.

This principle is not always recognized. Thus one of my censors has written:

> I fail to see that any good argument has been made to prove that the ecologist is called upon to discuss the genesis of land forms when describing any given region. I fail to see that plant ecology can be described in terms of "structure, process, and stage." The altitude of a given mountain range will be a far more important factor in the distribution of organic life than that its summit marks a peneplain or, as is often the case, a hypothetical peneplain. . . . . As I see it, a plant ecologist would first view a landscape from the standpoint of relief. Soil, the reaction of climate, and bed rock would perhaps be the second element. I fail to see where the genesis of land forms would aid him. . . . . I am convinced that the empirical description of regions must still maintain an important place in geography.

The implications of the first and the next to last sentences here quoted are interesting in that they exhibit a prevailing misapprehension as to the use of a genetic study of land forms: they imply that the genesis of land forms is in itself an object of geographical investigation, instead of only serving as a means of geographical description. This misapprehension is common among geographers whose greater interest is in some onto-

graphic branch of our science, and whose acquaintance with and interest in its physiographic branches is therefore small; it is illustrated in the essay on the Macclesfield district, referred to above, where "physiography" is made synonymous with geological evolution. Many a writer on economic geography feels that an empirical knowledge of land forms will suffice for him quite as well as for the ecologist, quoted above. Likewise many writers on what they call historical geography, who give to physical features only a paragraph that is nearly lost in the pages they devote to the human element, are satisfied with empirical and very elementary accounts of hills and valleys, mountains and coasts. Indeed, one such writer recently described the ranges of a mountainous region as having two trends, one "vertical," the other "horizontal," thus repeating in cold print on the pages of a leading geographical journal intended for mature readers, a blunder in map reading which should put a young pupil in an elementary school to shame. Such an essay might be called "pseudo-geographical *history*," but before it could deserve to be called "historical *geography*," and therefore merit a place in a geographical journal, its physiographic factors should be more thoroughly treated.

I am inclined, however, to believe that ecologists, zoölogists, economists, and historians, as such, are right in saying that an empirical knowledge of land forms will supply all the physiographic information they need; for my own experience has repeatedly convinced me that an empirical knowledge of botany and of economics is all that a physiographer, as such, needs: but just so far as ecologists, economists, and physiographers are thus satisfied, they will fail to become all-round geographers, and their regional studies will show an unbalanced, not a homologous, treatment. Regional studies will not reach full development until it is recognized that there is just as much need of giving thoroughly scientific treatment to one division of geography as to another.

As to the second sentence above quoted, the evident implication is that the writer's acquaintance with the scheme of "structure, process, and stage" has been too largely derived from this three-term name of the scheme, instead of from study and use of the scheme itself. This inference is confirmed by the third and fourth sentences, which suggest that factors so important as the altitude of a mountain range and the standard factors of relief and soil are omitted from the scheme. Climate is, of course, omitted, for that subject is treated in another section of physiography, as oceanography is in a third; but altitude, relief, soil cover, and many other matters are given due consideration.

Geographical Treatment of Ontographic Factors.—Although botany and zoölogy are thriving sciences, the manner in which plants and animals should be treated in regional geography is not yet well established. Mere lists of the plants and animals that occupy a certain region are as little appropriate in regional geography as are lists of mountains, lakes, cities, or railroads; such lists may have their importance somewhere, but

they do not aid a geographer in answering the test question of regional geography: "What does the region look like?" The description of organic forms apart from their inorganic surroundings is unsatisfactory, because it leaves out the most interesting and vital element of geography, namely, the relation of the environed to their environment. Minute and rare plants and animals are of about the same small or negligible geographical value as eminent and therefore exceptional men or as small and exceptional land forms; none of them make significant parts of the visible landscape. Studies of plants and animals in terms of their distribution, species by species, are important in geographical biology, but such accounts still leave nearly everything ontographic to be said in regional geography, because they do not present the various plants and animals as they are actually associated in a vivid picture of the region concerned. The lobe of a flood plain may be almost evenly covered with a well-established and rather uniform growth of trees, but it is characteristically interrupted by slashes or curved linear marshes, with water-loving plants, marking lines of flood-plain growth arranged in convex belts parallel to the outer and downstream or growing margin of the lobe; the trees extend in full force to the upstream, undercut margin, but the new-made, growing margin is occupied only by the most active and newly arrived colonizing plants.

The spaced growth of sagebrush in our western country is geographically more significant than the precise species of this much-subdivided genus. The eastward extension of the coniferous forest growth over the Cascade Range and its termination in dwindling points on each east-reaching spur crest, as the lower limit of tree growth rises with increasing aridity, is geographically more important than the precise species of conifers of which the forest consists. In the lower Connecticut Valley it is particularly on or near the rocky talus below the glacially refreshed west-facing cliffs of the discontinuous ridges formed by faulted, east-dipping sheets of resistant trap rock that rattlesnakes are still occasionally seen in the warm season; but the talus is much more visible than the snakes. On the south coast of Devonshire, a submaturely dissected morvan, recently a little submerged and therefore sea-bordered, the wave-swept cobble and sand beaches which swing in concave curves across the coves are bare of life, while the wave-cut rock platforms which front the young sea cliffs of the convex headlands are seen at low tide to be occupied by abundant sea anemones and limpets between the red-brown seaweeds. The hut-like hills made by termites on the South African veldt, and the paths of foraging ants on the pampas of South America, are larger elements of the landscape than the termites or the ants themselves. One often sees beaverdams and the ponded waters behind them in Rocky Mountain valleys, but the beavers that make the dams are rare elements in the landscape. The converging and uniting tracks worn in narrow lines of wavering course by pasturing animals on the way to and from the rare springs or pools of a dry country, and the usual appearance of the animals

as they walk or run along the paths in single file, are of greater geographical value than the precise specific description of the animals themselves.

How then shall plants and animals be geographically treated? It is evident that the terms in which they and their groupings and associations are presented in a regional description must be familiarly understood from previous analytical and systematic study; for here, as in the treatment of land forms, regional description must not be burdened with the preparatory explanations that should precede it. The preparatory explanations regarding plants of course involve a certain acquaintance with systematic botany, and still more an understanding of plant associations or formations, such as is furnished by modern ecological studies; but a minute knowledge of systematic botany is as unnecessary to a geographer as a minute knowledge of petrography. The preparatory explanations regarding animals naturally include a certain acquaintance with systematic zoölogy, and still more a knowledge of the visible habits of life of the larger animals; small animals have little geographical importance, unless, like grasshoppers, they sometimes fly in air-darkening, rustling flocks and devastate the surface where they alight; or unless they unite to work in vast numbers, like reef-building corals; rare or concealed animals may be neglected unless they temporarily become visibly abundant, like the palolo which once a year swarms around the shores of the Fiji and other islands to such an extent as to color the surface of the sea.

A practical difficulty ordinarily stands in the way of full success in this advanced chapter of geography. Most geographers today are much better trained and have a much greater interest in either the physiographic or the ontographic parts of their science, and cannot prepare all parts of a homologous regional description with equal competence or satisfaction. The only safe way to overcome this difficulty is to secure broader training and broader interest for the geographers of the future than the geographers of the past have had. The geographer who joins us from the side of botany will probably have an overabundant knowledge of plants and a deficient knowledge of animals and of land forms; he will be one-sided, predisposed to the intensive study of vegetation, while he passes too easily over other topics, just as many geographers who have joined us from the side of geology have been oversupplied with knowledge of the earth's history, and have given an excess of attention to the evolution of land forms and far too little attention to their inhabitants. Only geographers of the broadest training will be able to prepare well-balanced regional studies, avoiding the barrenness of uninhabited land forms and the desiccation of meteorological tables, as well as the vagueness and unattachedness of lists of plants and animals for which no habitat and no climate is provided.

Although the present paper is concerned chiefly with the physiographic half of geography, this section on plants and animals may be followed by another on cities, in order to indicate that even in those culminating

phases of human geography an explanatory and systematized scheme of treatment should be adopted in regional descriptions.

Geographical Treatment of Cities.—The treatment of cities in regional geography of advanced grade and detailed scale is a difficult problem on which no general agreement has been reached; for it is not easy to select from among the many complex elements which go to make up a city the particular items which are of truly geographical quality. The solution of this problem would be made simpler if geography were regarded—as some writers seem to regard it—as a mere compendium of useful or interesting information, for in that case many sorts of civic items, such as the organization of fire departments, the care of the poor, the method of conducting elections, and so on, would be pertinent. But such a definition of our science is not satisfactory: we must regard geography as in some reasonable manner limited on the ontographic side, so as to include only such civic items as enter into not too remote a relation with inorganic items, for otherwise it would trespass too far on history, economics, and sociology. It is possible that an analytical study of cities will in time lead to the establishment of a standardized scheme for their systematic geographical treatment, which will be as helpful to geographers as the standardized method of describing plants is to botanists, and that from such a systematic treatment a thorough regional treatment of cities may be developed; but no such analytical and systematic study has yet been so successful as to be generally followed to its regional applications. It may however be suggested that "What does it look like?" is as good a question with which to begin the geographical study of cities as of landscapes, and that in answering such a question not only the manner in which the city lies on the land, not only the nature and advantages of its situation, should be presented, but also the general appearance of the city itself, day and night, summer and winter. Trains of passengers and of freight arriving and departing, processions of men and women on their way to work in the morning and returning home in the evening, streams of children going to and from school in forenoon and afternoon, and many other similar features, should all be included, for these are all visible responses to the fundamental influences of light and darkness, and of warmth and cold, on the rotating, revolving earth. How many additional matters should be treated in the description of a city I shall not attempt to say. It would be profitable to see a systematic discussion of this difficult problem by a specialist, with particular attention to its regional application. In any case I believe that the treatment should be rational, explanatory, and even evolutionary, but not historical; that is, that all pertinent features should be treated in view of their present stage in the whole series of changes that they suffer during a city's growth, from its beginning in a village to its most flourishing development and perhaps to its end in vanishing ruins. The presentation of the growth and development of a city in historical order should be avoided as carefully as the presentation

of the erosion and development of land forms in geological order; what is needed is a statement of the existing condition and appearance of the city in terms of its historical growth, provided that the general sequence of changes in the growth of cities can be analyzed and systematized in some such manner as the evolution of land forms has been. Different kinds of villages and cities in different stages of development would then be recognized. There would of course be a very different presentation for different examples; for instance, an ancient and still thriving city, like Cologne, in an open plain on a great natural highway, still preserving in its name as well as in the narrow streets of slightly irregular rectangular pattern within its central part the long-enduring impress of settlement as a "Colonia" by the Romans, but now showing vigorous exogenous rings newly added by the modern Germans with broad avenues systematically planned; and on the other hand an upstart mining town, like Cripple Creek, already waning after a brief and hurried flash of excited life, because of the decreased yield of its mines, the opening of which tempted an eager population to occupy a mountainous highland, difficult of access and, apart from its mines, uninviting to settlement.

Arrangement of Regional Description.—There can be little question that the least satisfactory feature of regional description lies in the necessity of presenting in separate, successive paragraphs or pages the many kinds of things that occur together in natural but unsystematic groupings. It is comparatively easy to describe together all the hills and valleys of a district in one section of an article, all the lakes, streams, and waterfalls in following sections, all the climatic and weather factors in a fourth and a fifth section, all the villages and railroads in sixth and seventh sections, and so on; it is much more difficult to present in a brief word-picture the situation of a single village in an open valley between well-watered, tree-covered hills, where the steady outflow of a lake, ice-covered in winter, supplies power at a waterfall for factories in which the products of forest and field are prepared for shipment by a railroad that runs through farms along the valley of the lake-outlet to some other differently environed center of population; and so on through all the parts of the region concerned. Although all the geographical elements of a region occupy it simultaneously, they must be described in some reasonable sequence, for they cannot all be stated at once. A good sequence in essays by mature writers for mature readers treats, after briefly stating the location of the region considered, first, the land forms with their associated water forms; the ocean, in so far as it is included in the region under consideration, second; the climate, third; and then plants, animals, and men; but such an arrangement is rather for the convenience of the reader than for the restriction of the writer, who should certainly feel free to depart from this or from any other scheme if he thinks he can do so to advantage.

Under land forms and their waters, which are considered in this article in more detail than the other headings, it is desirable to begin with a concise,

simplified account of the leading features of the region, treated at once in explanatory style, and then to add successively longer statements concerning the smaller, subordinate, and detailed features, according to the scale of treatment adopted. Dominant forms, and not the most ancient forms, should receive first mention; subordinate forms should then be located in relation to the dominant forms. Examples of the influence exerted by land forms on climatic factors, plant growth, animal habitats, and human industries may be introduced here as far as one desires, thus preparing the way for the reversed order of statement when consequences are referred back to causes in later paragraphs. A similar plan seems advisable for the treatment of other geographical factors.

It is a serious mistake for any geographer, who adopts the explanatory method for the description of land forms, to open his essay with an empirical description and to postpone his explanatory description till a later page. The only reason for using an explanatory description of land forms is that it is more forcible and efficient than an empirical one; hence if used at all it should be presented immediately at the beginning. Yet there are many essays of recent date in which this principle is violated; one essay, for example, in which the forms of a district are first minutely described in empirical fashion, then its structure is set forth with much geological detail, and its rivers are all elaborately enumerated, before the reader is informed, on the fifteenth page, that the essay has to do with an uplifted and dissected peneplain. The only reason for introducing this concise explanatory phrase in any part of a truly geographical description is, not to reveal inferences as to the geological past, not to present the genetic history of the region, but clearly to set forth the essential facts of the geographical present by naming their mental counterparts in the brief words of an already familiar terminology. Why a simple phrase like "uplifted and dissected peneplain" should be postponed to the fifteenth page of an essay, instead of being placed on the first page, is difficult to understand. Perhaps the writer thought that he must give an elaborate and empirical justification before he ventured upon an explanatory phrase; but if so, he has adopted the wrong order of statement, for if the explanatory phrase needs justification, the justification should follow it, not precede it. Perhaps the writer thought that his readers could not understand the explanatory phrase unless he first empirically set forth the facts which it so concisely suggests; but if so, he mistakes the whole object of an explanatory terminology, namely, to replace an unsatisfactory terminology with a better one. Hesitation in this regard is indeed curious, for writers who are unwilling to state that a certain district is, for example, an uplifted and dissected peneplain until after they have empirically announced the facts that are thus implicitly indicated usually assume that their readers will understand, without any introductory explanation, such geological terms as Permian and Triassic. Evidently, then, their hesitation cannot be due to an intention to write for ignorant readers.

Whatever be the reason for the timid, half-hearted adoption of the explanatory method, a natural consequence of it is that the well-trained reader will often discover a postponed explanation before the author announces it, so that when it is reached it is a somewhat stale and unnecessary confirmation of a rather manifest inference. Mature geographers are not, as a rule, pleased with reading of that sort. Their intelligence is better satisfied if the explanatory statement is placed at the beginning.

After the land forms of a region along with the associated land waters are sufficiently described so that they may serve as the stage setting for all that follows, and after such part of the ocean as enters the region is treated, the leading factors of climate and weather should be introduced, not as isolated numerical averages, but as parts of large phenomena which have an essential place in the activities of the earth's atmosphere; and again, not as abstractions unrelated to the land forms already treated, but as realities closely associated with the land forms the habitability of which they determine. The land forms, already described, may be referred to in the section on climate as known elements, with respect to which local climatic factors stand in some reasonable relation. Illustrations of the consequences of climatic controls in the way of limiting plant growth, determining animal habits, and guiding human activities, may be at once introduced, if desired, partly in order to emphasize the value of climatic factors, partly in order to strengthen the idea of interconnection among the many elements of a geographical region. Then come plants, not in the order of systematic botany, but in their natural groupings, as determined by land forms with their soils, and by climatic factors, including ground water; the dominant plant formations first, the smaller ones later, and exceptional features, so far as they deserve notice, at the last; and so on through the whole essay. The plan of a regional description may therefore be called "cumulative," a plan of which the classic example is "The House That Jack Built"; but the mature geographer need not, when writing for his mature colleagues, imitate the highly explicit and redundant style that makes Jack's architectural epic so attractive to juvenile readers.

On each return to the fundamental elements of land forms and climatic factors in a description of mature grade, they may be touched upon more and more lightly, because they become more and more familiar through repeated citation; so that when the final section on human activities is reached the land forms and climatic factors that then need consideration will be sufficiently recalled by a very few words. But it would be a serious mistake to present a detailed, mature, and rational account of human and other ontographic elements in a regional description which gave only a brief, immature, and empirical account of the physiographic elements. The different parts of such a description would not be homologous. Much material that is presented under the heading of economic regional geography is, as has been pointed out above, faulty in this respect, however

important its subject matter may be: the physiographic basis with which it is satisfied is so elementary, and often so trivial, that its geographical quality is very doubtful; such material might be better left entirely to economists, under the title, geographical economics; it should not enter serious regional geography until it is found to demand a serious geographical knowledge for its basis.

Place Names in Regional Description.—A writer is of course familiar with all his mountains and streams and bays and villages, but his readers are not; and for the sake of his readers it is not so advisable for him to display his local learning by the over-free use of place names as it is to show his worldly wisdom by due consideration of the "honorable points of ignorance" on the part of those whom he addresses. In the introductory account of the leading features of a region only well-known place names, like Adriatic, Gibraltar, Michigan, Panama, Singapore, and Kashmir, should be used as a means of indicating locations. Great care should be taken in the following parts of the description not to indicate the position of an unknown element of land form by means of an equally unknown place name; this is not only indicating the unknown in terms of the unknown, it is placing the ontographic cart before the physiographic horse. The location of villages and other ontographic items should, when first mentioned, be stated in terms of the land forms that have influenced them; only after the location of such items has been thus made clear may their names be used as guides to the location of other items; but this good rule is repeatedly violated, with the result of making many geographical essays unreasonably difficult to read understandingly. The difficulty is, indeed, so great in some cases that many readers turn aside from the attempt to reduce it, and give their time to the study of more accessible material. It is eminently desirable that all the place names that occur in a regional description should be indicated on one or another of the accompanying maps, as is further suggested below.

Scale and Grade of Regional Description.—Regional descriptions for professional geographers may be written in detailed or in condensed form; that is, they may, like maps, be prepared on a large or a small scale. Just as a cartographer is expected to be expert in drawing large-scale, intermediate-scale, or small-scale maps, so a geographer should be expected to be expert in writing detailed, intermediate, or condensed descriptions. Regional descriptions may vary also in grade from advanced or professional to elementary or juvenile; and just as a cartographer should know how to draw on any scale minutely accurate hand-atlas sheets for the student, generalized wall maps for the mature public, or simple outline maps for elementary schools, so a geographer should be proficient in preparing regional descriptions of any scale in an advanced or technical grade for his colleagues, in an intermediate grade for the mature public, or in an elementary grade for school children. The best way to become proficient in this or any other art is to practice it under a

good teacher. Exercises in regional descriptions of different scales and grades are of great disciplinary value to earnest, advanced students of geography.

If a regional essay is not only prepared on a detailed scale, but is also incumbered with irrelevant geological detail and clogged with explanatory analysis, its geographical results will be almost inaccessible, and they will seldom be quoted. A detailed essay, even if limited to truly geographical matter, may be made more available for general use if a condensed and purely geographical statement of the leading facts is introduced at its beginning. Most readers will be satisfied to read such a statement alone; only the exceptional reader will read every page of a long article.

Regional descriptions vary not only in scale and in grade, but, like other methods of treatment, they vary also in style and in form. It has been objected that the use of a technical, scientific terminology will give geographical essays an unattractive style, and that the adoption of a systematic method of treatment will give them an undesirable rigidity of form. These unpleasant qualities are not necessary consequences of technical and systematic work. The chief value of a technical and systematic method of treatment does not lie in prescribing a rigidly uniform sequence of statement, but in aiding conciseness and completeness of statement. Successive topics may be presented in any unsystematic order that seems suitable, provided that none are thereby excluded. Technical terms are not incompatible with graceful phrases, even though technical writers are often indifferent about graceful phrasing. Method and terms, scale and grade, are matters upon which general agreement is desirable; style and form are personal matters in which each writer will follow his own preference.

Illustration of Regional Descriptions.—In view of the wide reach of geographical exploration and of the wide distribution of geographical literature in these modern years, it often happens that an article descriptive of one part of the world is published in another part and read in a third. Distant readers are probably little informed about the region described, and their ignorance should be carefully considered by the writer of the article, provided he is writing for the whole geographical world and not merely for a little corner of it. Hence his article may advisedly include, as an inset figure in its first paragraph, a small outline map of the country or the continent in which the region occurs, with a minute rectangle to indicate the location of the described region; and opposite to the second paragraph there may be a simplified outline map of the region itself, on which the chief physiographic features and all the important place names mentioned in the text are immediately indicated; the less important place names on a small map of this kind may be sufficiently designated by their first two letters. Such a map should differ from a general map of the region concerned in giving prominence to the chief subdivisions and places named by the author; thus it really illustrates the paragraph that it

accompanies. Shortly following the outline map a simplified block-diagram of the region is very helpful, for thereby the author's understanding of his problem is easily passed on to his readers. To be sure, such a diagram does not show merely the facts, but, as Passarge has correctly pointed out, the author's understanding and interpretation of the facts, and precisely therein lies its great value; for in any style of description it is only through the author's interpretation of the facts that they become known. If a detailed topographical map of the whole region can be provided to accompany the article, so much the better.

Special topics may be illustrated by detailed diagrams and maps, if desired; but if the distribution of certain elements over the region is thus graphically exhibited, care should be taken to see that the text presents these groups of elements in their proper relations to other elements, in order to give a vivid picture of the composite whole in which they are all united: only in this way can the essential quality of regional geography and its difference from systematic geography be properly emphasized; for while the latter properly enough treats things of a kind together, wherever they occur, the former strives to treat all the things that occur together, of whatever kind they may be.

When local details are reached photographs may be introduced, especially good-sized, clear prints from elevated points of view, without an excessive amount of meaningless foreground; but outline sketches should not be neglected, for they may represent features which photographs usually fail to show. The location and direction of photographs and sketches may be concisely shown, for the convenience of the reader, on the general map of the region by two arrows, joined in a V at the point of view, and indicating the area included in the picture by their divergence and length. It is sometimes urged by practical geographers that they cannot draw, and hence that their articles cannot be illustrated by original sketches and diagrams. It may be true that some very exceptional persons are so clumsy-handed that it is a waste of time for them even to try to learn to draw; but any person who has learned to write a fairly legible hand surely possesses sufficient manual dexterity to learn to draw helpful diagrams, if not to make recognizable sketches. It is as unreasonable to offer the excuse, "I cannot draw," in explanation of the absence of diagrams from a geographical essay, as to say "I cannot ride," as a warrant for making a distant exploration on foot. An explorer need not be discouraged if he is not a Bellerophon, for his mount will more likely be a Rosinante than a Pegasus; and he need not be disheartened if he is not a Holmes or a Heim, for enviable as their skill is in drawing outline landscapes, diagrams of much less artistic value are nevertheless very helpful as supplements to verbal descriptions.

Conclusion.—It is comparatively easy to lay down general rules; it is often difficult to follow them in their particular application. In regional geography the difficulty of passing from the abstract to the con-

crete is the greater because geographers are not yet well agreed as to the nature or the limits of their tasks. The chief object of this paper is therefore to call attention to a number of principles which, it is believed, will be helpful in indicating the nature of certain geographical problems, in concentrating attention upon the goal to be attained, and in marking the limits beyond which geographical studies need not be pursued. In illustration of the importance of analytical and systematic studies in all branches of geography as preparation for regional description, I have first instanced the nature of analytical and systematic studies of land forms in their relation to regional accounts of land forms; and then I have tried to show that analytical and systematic studies are equally useful in other divisions of geography in preparation for regional treatment. Evidently enough, the complex subject of regional geography, the goal of all our efforts, cannot be treated completely until the treatment of all its divisions has been fully developed.

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THE OASIS OF TUBA, ARIZONA

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CONTENTS

INTRODUCTION.—The Western Navajo Reservation, lying east of the Marble and Glen canyons of the Colorado and south of the San Juan River (Fig. 1), is a virgin field for geographic research. Its surface is wonderfully molded by a maze of profound canyons cut in brilliantly colored rocks, and upon its myriad mesas the winds of an arid climate have left their characteristic impress. Areas of bare rock and areas scantily clothed by specialized plant forms are interrupted at Navajo Mountain by a luxuriant garden of flowers, shrubs, and trees which would not be out of place in a New England landscape. Within this region are the Hopis, a remnant of an ancient race, the fundamental lines of whose history have yet to be written. In the midst of the ruined villages the vigorous and promising Navajos carry out their nomadic lives.

As yet the natural environment of Navajo and Hopi has been modified but little by the coming of the white man. Three widely separated trading-posts located near the edge of Black Mesa include all the white inhabitants outside the Indian Agency, and the total white population within an area of about 7,000 square miles is 63. Surrounding this handful of officials, traders, and missionaries, 6,550 Indians of three distinct races conduct their affairs with little regard to the wishes of a superior race. The only settlement of note within this undeveloped tract is on the Oasis of Tuba—a settlement with an uninterrupted history since times long antedating the dawn of American history.

The pioneer route to Tuba from Salt Lake City crossed the Colorado River at Lee's Ferry, while the route from the south followed the desert floor of the Little Colorado Valley. By the construction of the Santa Fe Railroad a better approach was afforded via Flagstaff, and the 80-mile

stretch of grass-dotted flat and bare desert between the railroad and Tuba has become the most used north-south route across northern Arizona. The road is rough and water is obtainable during the dry season at only one place; but in comparison with other lines of access, this route is highly satisfactory. The construction (1912) by the government of a suspension

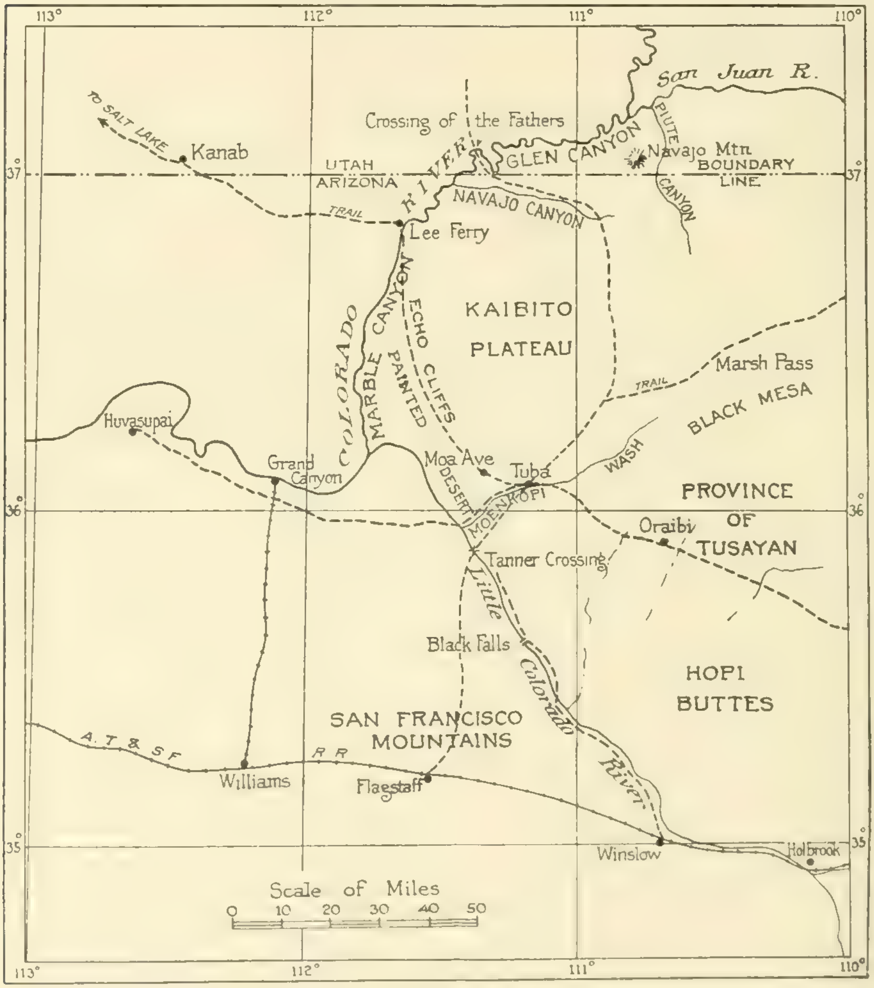

FIG. 1.—Map of a portion of Northern Arizona and Southern Utah, showing the geographic setting of Tuba Oasis. The trails, indicated by broken lines, are centuries old and are still utilized by the Indians and in part also by the Whites.

bridge across the Little Colorado has eliminated Tanner's Crossing, whose quicksands have claimed their toll of goods and lives since the days of the first pioneer. Traveling in an automobile, one may pass through the forests of the San Francisco Mountains, down the long, bare slopes of San Francisco Plateau, cross the canyon of the Little Colorado high above

its bed, and make his way across the heated floor of the Painted Desert to the orchards and groves of Tuba. By this method of travel scant appreciation is gained of the hardships and dangers involved in attacking the desert—the task of the Indians for centuries and of the whites for the last fifty years.

Tuba is perched on the edge of Kaibito Plateau, a windswept, dune-dotted tableland overlooking the beautiful but inhospitable Painted Desert (Plates I*a* and III*b*). The south and west edges of the Oasis are defined sharply by the walls of the Moenkopi Canyon and the escarpment of tilted rock forming Echo Cliffs. On the east, Reservoir Canyon marks the border of unreclaimed desert. At the north, beginning at the edge of the cultivated fields, the wind has undisputed control. The Oasis and adjoining areas have an elevation of about 5,000 feet, and aside from Reservoir Canyon the topography consists essentially of two classes of features: fantastically carved buttes, tables, needles, and bobbins of bare rock, and dunes of varied expression. The rocks are red and greenish-white in tone, the dunes are yellow-gray, and the landscape presents a strikingly different aspect with each stage of the sun's daily advance and with the passing of infrequent clouds. Moenkopi Canyon, on the south edge of the Oasis, is a nearly vertical-walled watercourse cut 200 feet in brilliantly colored strata. Along its butte-dotted floor, one-half mile in width, the Moenkopi has intrenched itself in an arroyo of alluvium 10–30 feet in depth. Reservoir Canyon likewise is bordered by sheer walls, in places overhanging, of massive, bright-red sandstone. Its wide floor, watered by numerous springs and hemmed in by continuous walls exceeding 100 feet in height, constitutes an ideal natural pasture. Tributary to Moenkopi and Reservoir canyons are many short, bare-floored arroyos which provide an escape for the storm waters falling within a few hundred feet of the larger canyons. On the Oasis as a whole, however, and within the surrounding desert, stream channels are not continuous and the run-off from the southern half of Kaibito Plateau is negligible. The water which falls is absorbed by the thirsty sand and rock or quickly returns to the air. Typical views of the desert border of the Oasis are shown in Plates I*b*, II*a*, and II*b*, which may be compared with Plate III*a*.

Climate.—The climate of the Tuba Oasis is local; topography and elevation are the controlling factors. The keynote of the climate is variability. Canyon and adjoining mesa and even opposite canyon walls have dissimilar climates. The summers are hot, the winters are cold; daylight is synonymous with heat, and darkness with chilliness. Annual, seasonal, monthly, and daily rainfall, temperature, and wind are subject to wide variations.

Miscellaneous precipitation records have been kept by volunteer observers at Tuba for thirteen years (1897–1913), including seven complete years, 1899, 1906, and 1909–13. While not adequate for comparative climatic studies, these records are sufficient to indicate the general features

of the rainfall. The mean annual precipitation for the five years 1909–13 was 7.08 inches. The mean obtained from the average of all months for which records are available is 5.30 inches. This latter figure is believed to be more representative, since it takes into account a series of unusually dry years not represented in the period 1909–13. In any event the value for mean annual precipitation, when it falls to such low figures, has little geographic significance. Annual and seasonal distribution of rainfall are, however, matters of fundamental importance in the life of a desert people. In 1899, 8.38 inches of rain were recorded at Tuba, while 1900, for which six months' figures are lacking, is known as "the year of the great drought." In 1901, with one normally dry month (April) lacking, the rainfall was 2.60 inches, and it is probable that the total precipitation for the four years 1900–03 was little in excess of that received in 1899. On the other hand, 12.57 inches of rain fell during 1906. In a region where the maximum precipitation is insufficient for agriculture and in places even for grazing, these great variations from year to year are matters of economic concern.

Of more direct interest to the native farmer and stockman is the amount of rain received in corresponding months from year to year. During the thirteen years under observation, precipitation has varied widely, and every month except March, July, August, and October has experienced the absence of perceptible rain. The figures, in inches, are as follows: January, 0 to 2.00; February, "trace" to 2.03; March, 0.16 to 1.59; April, 0 to 2.58; May, 0 to 0.75; June, 0 to 0.75; July, 0.19 to 1.90; August, 0.09 to 1.66; September, 0 to 1.98; October, 0.15 to 1.84; November, 0 to 2.92; December, 0 to 1.77. May, with an average of 0.11 inch of rain, is the driest month, and November, with 0.58 inch, the wettest. Winter, with a precipitation of 1.57 inches, is the rainy season. The figure for the fall months is 1.49 inches; for summer, 1.28 inches; and for spring, 0.96 inch. A more significant grouping of months for this area is a "rainy" season, including October, November, and December, during which time 1.70 inches, or 32 per cent, of the rain falls; a dry season, April, May, and June, with 0.66 inch, or 12 per cent; and two intermediate seasons, January, February, and March, and July, August, and September, which record respectively 1.49 and 1.45 inches. May and June combined average 0.29 inch per year. The significance of these figures lies in the fact that April, May, and June are the growing months for most field and forage crops in the temperate zone, and that May and June are the months usually relied upon to produce a vigorous growth. These three months combined received at Tuba less than 0.5 inch of rain for five out of fourteen years, and only once in fourteen years did May receive more than 0.34 inch. Moreover, plants receive only a portion of this meager supply, for evaporation is most effective during the dry, hot, clear days of early summer. The specialized native plants and the selected varieties of native corn make free use of the water stored in the ground by the winter

rains and snows, which, supplemented by the occasional showers of spring, is in normal years adequate to permit seeds to germinate and to send their shoots above ground. The precipitation during winter and spring is not, however, sufficient to bring a crop to maturity. The rainfall of July therefore becomes the critical climatic factor. With July rains, corn succeeds without irrigation on the Navajo Reservation; without them, the crop is a failure. For eleven out of thirteen years the precipitation at Tuba during July, following a greatly deficient rainfall in May and June, was less than 1 inch. During five of these years less than one-half inch fell. Under such conditions the raising of corn and forage crops without irrigation on the Tuba Oasis is doomed to failure, except in highly abnormal seasons.

The typical rainstorm of the Tuba Oasis is one poorly adapted to assist in raising crops. Gentle showers continuing throughout a day are of very rare occurrence. The supply is normally furnished by thunder showers of extreme violence lasting less than an hour. In a number of instances the total precipitation of a month has come from a single shower; e.g., the April rain for 1913, 0.12 inch, fell on April 2. The area wet by showers is usually a few square miles and not infrequently only a few hundred acres. Immediately before and soon after these showers bright skies and high temperatures are in evidence, and the ground and clothing are dried so quickly that a tent, even during the rainy season, was found to be superfluous baggage.

Heavy thunder storms may occur at heights of 2,000 to 5,000 feet without wetting the ground, and on one occasion the only result of a severe upper-air storm was the falling of a few dozen hailstones. Lightning is an almost invariable accompaniment of showers; scarred trees accordingly are familiar sights on the higher parts of the Western Navajo Reservation, and this area is included in the region of maximum damage by lightning, as determined by the Bureau of Forestry. On two occasions my camp equipage was struck by bolts. The Navajo has good reason for his belief in the vindictive power of the "lightning people."

The mean annual temperature at Tuba is 52°.1. The mean of the warmest month, July, is 77°, and of the coldest month, December, 30°.5. The mean monthly temperatures of spring, summer, and fall show moderate differences from year to year, but December and January exhibit substantial variations. Thus, the December mean for 1898 was 23°.7; in the following year, 38°.7. In 1898 the January mean was 23°.2, replaced in 1900 by a mean of 43°.2. Temperatures above 100° are rare, being recorded on two occasions only during the three years 1910–12. During the same period, Holbrook, in the Little Colorado Valley, 100 miles south of Tuba, recorded 35 such days, and Hite, in the Colorado Valley, 110 miles north, had 101 days with temperatures exceeding 100°. Extremely low temperatures likewise are not characteristic of Tuba's climate. The thermometer recorded 73 days with temperatures of 15° or below for the three-year

period 1910–12, and four days with temperatures below 0°, viz., November 3, December 26, January 27, and February 6. The lowest temperature recorded is −13° and the highest 108°, giving an absolute range of 121°. Snow falls in normal years during one or all of the winter months, and attains an average annual depth of about 6 inches. The average dates of killing frosts are May 13 and September 23, thus giving a growing season of 133 days, ample for grains and most fruits. In exceptional years frost has come as late as June 5, and has killed plants as early as September 19.

As in most other arid regions, the heat of the day begins abruptly with the rising of the sun and continues to sunset. During the middle of the day instruments and camp utensils, as well as rocks exposed to the sun, may not be touched without pain. The great heat and the high daily range fortunately are accompanied by low humidity. The records at Flagstaff, 80 miles southwest, give a mean relative humidity for the year of 62 per cent, dropping to 39 per cent in June. This station receives 81 per cent of the possible amount of sunshine. The Oasis of Tuba is less humid than Flagstaff, and on the average has probably 250 clear days during the year. Sunlight is associated with heat and shade with cold, and the boundary between areas of unlike temperatures is sharply drawn at the edge of a shadow.

Soil.—The local soil of the Tuba Oasis is weathered from lime-cemented quartz sandstone including lenses of limestone, and to it is added dust carried by the wind from the argillaceous, calcareous, and volcanic rocks of the Little Colorado Valley. The oriignal organic constituents of the soil are supplied by roots and branches of semi-desert flora, buried each season by wind deposits. The alkali present, though not large in amount, is sufficient to demand care in the selection and cultivation of crops.

Flora.—The climate of the Tuba Oasis is unfavorable for the growth of plants, except those adjusted to arid conditions. At springs and on the damp floors of canyons, tules and water-loving grasses and herbs maintain a vigorous growth. A few feet from water-soaked soil low, wide-spaced individuals or small groups of greasewood, sage, rabbit brush, yucca, and cactus form the vegetal cover. Goldenrod and other Compositae find a foothold in favored localities. Following rains, diminutive, short-lived, but brilliantly flowering plants of several species form pleasing bits of color. A few weatherbeaten cottonwoods at Moa Ave and on the floor of the Moenkopi Canyon, and a grove of small, scattered cedars four miles north of Tuba included all the trees near the Oasis at the time of the Mormon occupation in 1878. The nearest piñons were 15 to 20 miles distant, and yellow pine, suitable for timber, was brought from the San Francisco Mountains or the north rim of the Black Mesa across fifty miles of desert.[1]

[1] This information was kindly furnished by A. B. Randall, of St. Joseph, Arizona, a member of the Mormon pioneer band.

Hough has shown[1] that the Hopis and their ancestors, the cliff people, were wonderfully adjusted to their plant environment. Of about 150 indigenous species, 144, including certain duplicates, were used for food, architecture, medicine, dress, or in religious ceremonies. Almost every plant is used in some way by the Hopis, and there is none for which they have no name. For these people, who are capable of running 100 miles without stops, it is a matter of small moment that pine boughs must be brought from the San Francisco Mountains, wild tobacco and flax from the Little Colorado, and wild berries from the highlands along the San Juan. Of 40 plants used as food, including roots, stems, leaves, and seed, the highly specialized Hopi corn takes first rank. In fact, the culture of the Kisani race, to use the convenient Navajo term for the Hopis and their ancestors, may be said to be based on the corn plant. For purposes of dress and adornment six species of plants were considered suitable. That two of them, yucca and cotton, were long in common use is attested abundantly by seeds, stalks, and fragments of cloth found in ancient ruins. The cotton of the Tuba Oasis (*Gossypium Hopi* Lewton) is a distinct species as respects structure and manner of growth.[2] It ripens earlier than other known species, a feature which has permitted adjustment to the inhospitable climate of the Navajo country.

Owing to the industry and foresight of the Mormon colonists, the government farms and gardens on the Oasis of Tuba furnish an unusually large variety of fruits, vegetables, and field crops. Like true agriculturists, the Hopi Indians at Moenkopi have tried out seeds obtained from the Spaniards and later explorers until their fields include upward of 25 kinds of cultivated plants utilized as food and medicine.

FAUNA.—The area adjoining the Oasis of Tuba is the home of reptiles and rodents. Snakes are common and lizards occur in abundance. During the course of a day's field work, on several occasions, more than 100 brightly colored lizards have been noted scurrying across sand dunes and bare rock or partially concealed among sage and greasewood. Field mice and field rats make their nests at the base of scattered clumps of brush and in crevices of rock; and prairie dogs are found along the floor of the larger washes. During some years rabbits overrun the country; at other times they are rarely seen. Of beasts of prey the coyote is the most troublesome, and the shepherds must be on guard constantly against the raids of these skilful marauders. In addition to rabbits, prairie dogs, and wild fowl, the ancient and modern Indians made large use of the antelope, which until about 1880 grazed on the grasslands and utilized the waterholes in the region between the Little Colorado and the San Juan. Judging from the traditions of Hopi and Navajo, hunting and trapping the antelope must

[1] Hough, Walter: "The Hopi in Relation to Their Plant Environment," *American Anthropologist*, X (1897), 33–34.

[2] Lewton: "The Cotton of the Hopi Indians," *Smithsonian Misc. Coll.*, LX (1912), No. 6, 1–10.

have engaged the energies of plateau Indians, at certain seasons, for many centuries. The introduction of sheep and goats has relieved the Indian of much anxiety regarding his meat supply; and the eating of reptiles and insects, the resort in times of famine, now is practiced rarely.

WATER SUPPLY.—Absorption of the rainfall on the Kaibito Plateau is favored by porous rock and wind-blown soil, while the arrangement of strata is favorable for the retention of water at a horizon within 100 feet of the surface. In places this water table has been brought near the surface and even exposed by dissection, producing groups of springs to which the Oasis of Tuba owes its existence. With the exception of the springs and of the water made available by recent trenching of the alluvial fill in Moenkopi Canyon, no permanent supplies of water for irrigation or for domestic use are found within a radius of 25 miles from Tuba.

The location of springs and the geologic conditions which determine their presence in the Tuba region are shown diagrammatically in Fig. 2. The springs issue from joints in the sandstone and from the contact of

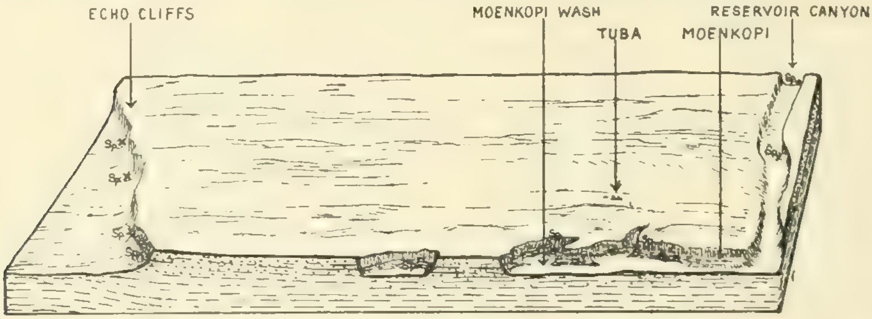

FIG. 2.—Diagram illustrating the conditions controlling the emergence of ground water on the Tuba Oasis. The front of the section is the north wall of Moenkopi Canyon.

massive, porous, cross-bedded sandstone with underlying thin-bedded sandstone and shale. The water is brought to the surface by two processes: exposing the water-bearing horizon by the cutting of canyons, and reducing the thickness of the upper bed by weathering and eolian abrasion. Thus the interesting phenomenon is presented of increase in available water supply without increase or even with possible decrease in amount of precipitation. Before the cutting of Reservoir and Moenkopi canyons the springs now issuing from their walls were represented by others which emerged far to the west in cliffs facing the Little Colorado. Also, during the time that the sandstone forming the floor of the plateau retained its normal thickness of several hundred feet it is unlikely that ground-water would have found its way to the surface near the site of the Tuba school. At the present time the sandstone has been eroded to such a degree in certain places that the water-bearing beds are within the reach of shallow wells. I am informed that in selected localities the Mormon colonists were accustomed to provide water for stock by blasting shallow holes in

dry, windswept rock. On the other hand, a shaft sunk to a depth of 212 feet at the copper mines, 35 miles north of Tuba, failed to recover water.

The changed habit of the ephemeral streams of the Tuba region has resulted also in increasing the amount and permanency of the water supply. Since about 1885 the Moenkopi and its tributaries have trenched their alluvial floors to depths of 15 to 30 feet, in many places exposing bedrock. By this process the amount of water in Moenkopi Creek at Tuba is said to have increased 600 to 800 per cent between 1878 and 1903.

Another interesting feature of the water supply of the Oasis is the burial of springs and spring-fed rivulets by drifting sand. More than a mile of Reservoir Canyon has been obliterated by traveling dunes, and the visible springs and seeps gradually are lessening in number (Plates III*b* and I*b*).

Without irrigation, agriculture is possible only in the immediate vicinity of springs, and the habitability of the Oasis is maintained by diversion of water at the springs and by extending ditches from the Moenkopi.

THE HUMAN POPULATION.—*The first settlers.*—The Oasis of Tuba, with its water and tillable land and its protective zone of surrounding desert, afforded a favorable site for settlement by a band of peaceful, agricultural Indians. Ruins near Tuba, at Honogee (Plate II*b*), and the mass of débris over which the present Hopi village of Moenkopi is built, indicate a very ancient occupation. Doubtless the Oasis was utilized for permanent settlement or as an outpost for villages at Tusayan or on the Little Colorado at Black Falls at a period long antedating the Spanish invasion. That the place was insignificant as compared with the more prosperous Kisani pueblos of the sixteenth century is suggested by the derisive term "Rancheria de los Gandules," applied by Oñate in 1604.[1] Whatever the date of the first settlement, the ruined buildings and abandoned fields, as well as the tribal traditions, indicate that the ancient inhabitants of the Oasis were ancestors in direct line of the present Hopi farmers.

Coming of the Piute and Navajo.—The Oasis of Tuba with the near-by springs at the base of Echo Cliffs affords the only reliable supply of palatable water over a vast expanse of desert south and east of the Colorado canyons and the only place where corn may be raised with comparative ease. It has served, therefore, as a station on routes across the Plateau Province (Fig. 1) since the days of the earliest inhabitants. Trading and foraging expeditions from the Havasupai and Walapai settlements on the lower Colorado, hunting parties of Piute and Navajo from north of the Colorado canyons, Spanish explorers, Mormon emigrants, and government scientific expeditions have utilized the Tuba route. To the roving bands of Piutes the Oasis was particularly attractive, and as their strength increased raids were made more and more frequently on the fields and homes of the Hopi. Following the Piutes came the Navajos, who on account of superior horsemanship and skill in warfare dispossessed Piute

[1] *Colección de Documentos Quéditos*, XVI (1871), 276.

and Hopi alike and rendered the Tuba Oasis no longer continuously tenable by an agricultural people. From the middle of the eighteenth century to the date of the Mormon colonization the fields at Moenkopi were cultivated intermittently by farmers who made their homes in the well-protected village of Oraibi, 40 miles distant. Garces, in 1776, found on the Oasis a "half-ruined pueblo . . . . which had been a pueblo of the Moquis, and that some crops which were near to a spring of water were theirs, they coming to cultivate them from the same Moqui pueblo [Oraibi] which is so large."[1] Judging from traditions, a few Hopi men, reluctant to abandon their excellent and much-needed fields, remained for a year or two at a time, and a few Navajos appear to have planted cornfields from time to time. Life under these conditions was precarious and attempts at agriculture most discouraging, and it occasions no surprise to learn that Jacob Hamlin, in 1874, found at Moenkopi "only one Piute family and an Oraibi woman."[2] An interesting side light is thrown on this distressing period in the history of Tuba by the fact that the Pakab (Reed) Clan of Moenkopi includes the chief of the Hopi Warrior Society.

The Mormon occupation.—Missionary enterprises of the Latter Day Saints led to a series of expeditions south of the Colorado Canyon. Between 1858 and 1871 Jacob Hamlin, with a few companions, conducted seven excursions to Oraibi, crossing the Colorado at "The Crossing of the Fathers," Pierce Ferry, and Lee's Ferry. During the course of these expeditions much information had been obtained regarding the Tuba Oasis and the Little Colorado Valley, and on the basis of favorable reports the "saints were called to settle in Arizona." Disastrous experiences in the Painted Desert forced the return to Utah of the large group of emigrants who crossed the Colorado in 1873; the one family left at Moenkopi in that year was forced by the Navajos to leave in 1875. Settlement by a few families was effected in 1876, and two years later occupation of the Oasis was placed on a permanent basis (Plate IV*a*). At first the abandoned fields in Moenkopi Wash were cultivated; later, fields were prepared near the springs on the upland, and Reservoir Canyon and Moa Ave were brought under cultivation. Corn, wheat, and garden crops were harvested and a few years later fruit and the flesh of cattle and sheep were added to the food supply. The conditions of life for the Mormons were hard, for, in spite of its fertility, the Oasis is small and the white population never exceeded twenty-five families.[3] Previous to the construction of the Santa Fe line (in 1883), which brought the Oasis within 80 miles of a railroad, supplies had to be brought over the long trail from Salt Lake City, 450 miles distant, or carried by wagons over the 370-mile stretch of difficult road leading from Albuquerque. Only light loads could be

[1] Translation from Coues, Elliott: *On the Trail of a Spanish Pioneer*, II, 358.

[2] Little, Joseph: "Jacob Hamlin," *The Deseret News*, Salt Lake City, 1909.

[3] Personal communication from the historian of the Latter Day Saints, 1914.

carried, and a round trip occupied from two to four months. Little fuel except brush was at hand and the nearest timber for building was found at the San Francisco Mountains, 50 to 60 miles distant across the treacherous Little Colorado. The climate, at all times inhospitable, was particularly unfavorable during the period 1898–1903. The year 1900 is known as the "famine year." No water flowed in the Moenkopi; the smaller springs dried up; and the flow of water from the big springs at Tuba was too meager for irrigation. No grass grew on the plains or in the washes; cedar and piñon died on the ridges. Sheep and horses perished for want of forage. The Navajos were reduced to a diet of bark and horse meat, and the Mormons faced starvation. The struggle of the pioneers for a livelihood was made more difficult by the continued hostility of the Navajos. Stock was killed or stampeded; fields were overrun by horsemen; irrigation ditches were broken and several white men were killed. By a process of "following and pacifying," combined with judicious trading and diplomacy, friendly relations were established, and certain well-disposed Navajos and Piutes were permitted to establish themselves on the borders of the Oasis.

To the Hopis the coming of the white man was welcome. Under the protection of a stronger race, the farms of their ancestors, practically abandoned for 250 years, were reoccupied. In 1880 Tuba (after whom the Oasis is named) and his family appear to have been the only Hopis residing at Moenkopi throughout the year. Gradually more families came in, many of them returning to Oraibi each year after the crop was harvested, and by 1903 probably 100 people of the Hopi race had made their permanent home on the Oasis, planting their corn and caring for sheep.[1]

Occupation by government officials.—Following disputes over land titles the Oasis of Tuba came under government control in 1903. In legal phrase it was "purchased" for $45,000, and the Indian Office took possession of the only spot within an area of 7,000 square miles suitable for an administrative center. The Mormon pioneers, removing to St. Joseph and other points in the upper Little Colorado Valley, took up anew their accustomed task of reclaiming the desert, and the burden of caring for the fields at Tuba fell to the lot of civil-service employees. From the standpoint of agriculture the change in ownership has resulted in loss. The necessity of obtaining an adequate food supply from a small acreage led to a high grade of intensive cultivation on the part of the Mormon colonists; government officials are, however, under no obligation to support themselves from the yield of local fields, and if occasion demanded it all food for man and beast could be obtained from outside sources. The government at Tuba is a dispenser of charity rather than a commercial enterprise, and agriculture is practiced for the benefit of the Indians, not as a means of self-support.

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[1] I am indebted to Mr. Walter Runke, superintendent of the Western Navajo Reservation, for this recent Hopi history, obtained from Pole-Hongevi, grandson of Tuba.

On this basis the plans for constructing reservoirs and for recovering the flow of the Moenkopi merit approval in spite of the many unsuccessful experiments and of a cost not justified from a commercial standpoint. The conditions warrant the reclamation and enlargement of the fields formerly cultivated by the Hopis and Mormons. As shown on the map (Fig. 3) about 40 acres of land on the school grounds at Tuba are irrigated by three springs which have a combined daily flow (1908) of 116,329 gallons, or about 0.50 acre-feet. At an estimated cost of $13,500 the

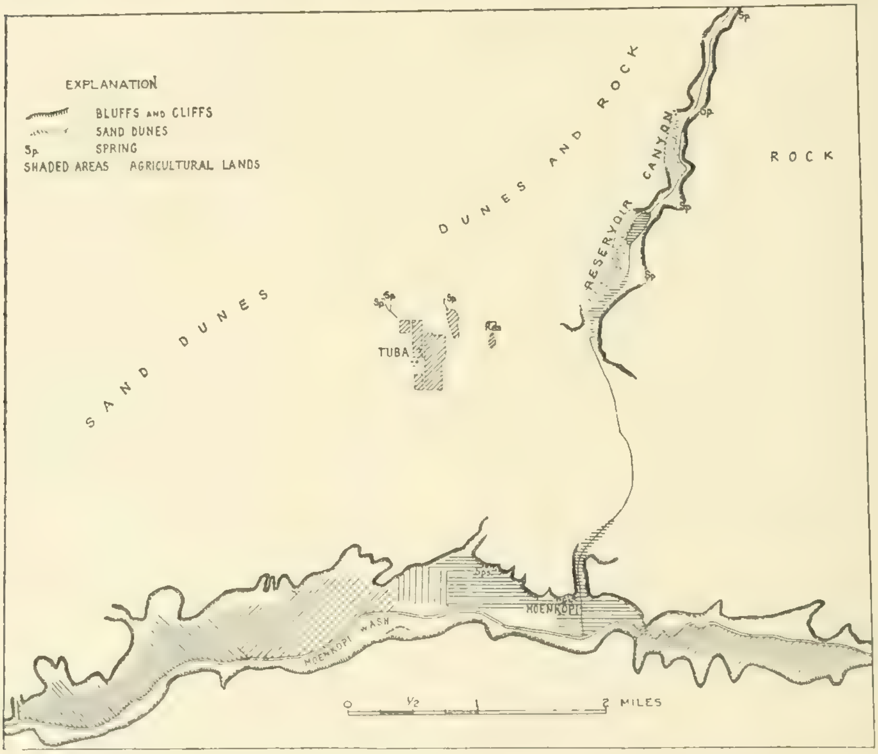

FIG. 3.—Map showing distribution of agricultural land on Tuba Oasis with reference to water supply.

supply of water could be made more certain and the tillable acreage somewhat increased.[1] Reservoir Canyon affords admirable pasturage, but is not suitable for farming. The flow from the Moenkopi, combined with that from Reservoir Canyon and the surplus from springs in the canyon wall, is capable of watering about 1,000 acres on the floor of Moenkopi Wash. On these irrigated lands, corn, wheat, and alfalfa produce large yields; vegetables of all sorts are readily grown, and fruit culture yields surprisingly large returns. Tuba apples are famous.

[1] Figures obtained from an unpublished report by Rollin Ritter, on file in the Office of Indian Affairs, Washington.

Agriculture, however, is a minor part of the duty of the government officials. Tuba is essentially a school with indoor and outdoor teachers. The children of Navajos and Piutes are brought in from the traveling camps of their parents, housed, fed, clothed, and taught. The stockman teaches the Indian better methods for increasing, improving, and caring for sheep and cattle; the farmer teaches the Indian while employing him in the planting and care of crops. The physician teaches sanitation and points the way of escape from the dreaded prevalent diseases, tuberculosis and trachoma. The task of the missionary is peculiarly difficult and, like those of his predecessors, the Spanish priests, his efforts so far have yielded small returns.

Under the protection of the government the Hopi population at Tuba has increased by migration from less favored localities until in 1914, 210 to 225 members of this tribe made their home on the Oasis. In addition to these permanent settlers many of their relatives reside at Moenkopi during the growing season. I am informed by Superintendent Runke that each marriage of a Moenkopi resident with man or woman from the Tusayan villages usually results in the founding of a new home on the Tuba Oasis. Like their ancestors of the Kisani race, the present Hopi are skilful agriculturists and the only important change in their life during the past centuries has been the substitution of mutton for the flesh of wild animals. They retain the ancient type of dwelling, conduct their time-honored ceremonies, and closely follow the traditions of their ancestors. Like the Hopis of the Tusayan province, the inhabitants of the Moenkopi village are clannish, independent, and desire to be let alone. The efforts of missionaries are particularly annoying to them. They ask nothing of the government except protection from the Navajo raiders and an occasional opportunity for remunerative employment. With their excellent fields of corn, wheat, melons, squashes, and fruit, and their carefully tended flocks, the Hopis of the Tuba Oasis are essentially self-supporting (Plates IV*b* and V).

The 6,000 Navajos and 200 Piutes under the Tuba jurisdiction have undergone little change as the result of enforced contact with the whites. About 200 of them haltingly speak the English language and wear modern attire. A few Navajos have farms on the Oasis; the others, continuing to lead their nomadic lives, come to the agency only for purposes of trade or for temporary employment.

Tuba is an attractive spot. Contrasts of desert and oasis are in few places better displayed. As a center for the study of the adjustment of unlike races to changing conditions of physical and human environment, it offers an unusual opportunity for detailed geographic research.

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NATURAL ECONOMIC REGIONS

CHARLES R. DRYER

CONTENTS

Recent Recognition of Natural Regions.—In recent geographic literature may be found many signs which point to the division of the earth into natural regions as an imminent and necessary step toward the solution of the ultimate problem of geography. The multiplication of regional monographs in France, the classification and mapping of natural landscapes by the Germans, the work of Herbertson and the Oxford School, the textbooks of Unstead, Newbigin, and Dryer, and recent papers presented before this Association may be cited in evidence. Many maps of natural divisions are in general use, of which those based upon relief and structure, or relief and vegetation forming natural landscapes, are most common. The cartographic representation of temperatures and of rainfall phenomena is receiving a great deal of attention, reaching its highest development and complexity in the map of climatic regions by de Martonne. The botanists and zoölogists are devising generalized maps of plant formations and animal realms. While none of these can satisfy the requirements of the regional geographer, they constitute essential contributions to the definitive map of regional geography which will, sooner or later, emerge.

A Guiding Principle for the Delimitation of Natural Regions.—Scientific method forbids any artificial, Linnean system based on one or two characters, demands that a delimitation of truly natural regions must take into account all the natural factors, and promises to make the problem sufficiently complex. If a generally acceptable solution is ever to be reached, some agreement as to the principles which are to govern the process is imperative.

That between the contents of any unit of crustal space the relations are far more than spacial is the fundamental postulate of scientific geography. The pedographic, hydrographic, atmospheric, and biologic elements fit into one another with an organic adaptation, forming a definite natural complex. To doubt that the fitness of all the physico-chemical factors

is perfect and complete would be scientific insanity. While the adaptation of plants and animals to the environment is perhaps never complete, it must be at least sufficient to make existence possible, and in the course of evolution must tend toward perfection. The greatest discord arises in the case of man, who brings into his environment inherited, traditional, and imported characters which are more or less a misfit or are not included in the general harmony. To discover the vital relationship between the higher elements of human culture and the environments in which they are acquired is perhaps a hopeless task, but the economic relations between human life and its physical and biological environment are easily demonstrable. This is true of all stages of culture. The North American Indian adapted his meager economy to a corresponding range of resources and conditions—chiefly game, fish, forest, climate, and mobility by water. The present occupants of the same environment are fast expanding their economy to embrace the utilization of every resource and condition, but the economy of the twentieth-century American is based as truly upon grass, grain, trees, cotton, coal, iron, and copper as that of the Indian was upon fish, deer, flint, bark, and skins. May we not find here a clue for guidance in the identification of what Herbertson calls the higher geographic units? Environments derive their meaning only from something environed, and that which gives them supreme significance is human life. If dividing the earth into natural regions is worth doing at all, is it not because it will facilitate the study and presentation of the relations existing between human activities and natural environments? The final cause of a natural region, in the Aristotelian sense of an end to be realized, is economic. If the industries and occupations by which men get or can get a living in a given natural region are not distinctive and different from those of the surrounding territory, that region, as delimited, lacks essential unity and utility. Here the geographer may be sure of his ground. By confronting every natural complex with an economic complex it will be compelled to reveal its essential geographic significance. In *economic influence* may be found a standard for estimating the relative value of the different factors which make up a composite natural region.

Climate and Vegetation as Factors in a Natural Economic Complex.—Unstead and Taylor, in elaborating their scheme of natural regions, thought it necessary to consider only those outstanding differences of relief, climate, and natural resources which have the most marked influence on the development and activities of man. The natural factor on which man is most directly and universally dependent for food, clothing, shelter, implements, heat, light, and power is vegetation. This dependence is in part through the mediation of animals, whose chief function in the economy of nature and of man is to convert vegetable matter into more efficient forms. The plant life, actual or possible, in any region is determined in part by the soil, but in plant ecology the edaphic factors are regionally subordinate to the climatic. The vegetative covering of the

land may be taken as an outward and visible sign of complex and critical conditions of temperature and moisture in the atmosphere and soil. Gannett even used vegetation to fill in blank spaces on the map of rainfall. The economies which exploit vegetation are plucking, lumbering, herding, and agriculture in their various phases. The relation of each of these economies to each of the great plant formations is direct and obvious. The plant formations are directly dependent on climate, and conform broadly to east-west thermal belts. The critical isohyets of ten, twenty, and sixty or eighty inches intersect the isotherms and break up the temperature zones into climatic regions. The map of climatic regions forms a close replica of the map of plant formations. Temperature and moisture control vegetation, which is the basis of human economy. Professor Friedrich of Leipzig, in the last edition of his *Geographie des Welthandels und Weltverkehrs*, publishes a map of economic zones and regions which is a copy, with slight modification, of Herbertson's map of "Major Natural Regions." He gives an elaborate analysis of the economic products, commerce, and transportation of each region, and shows that climatic, phytographic, and economic regions are substantially identical. This geographer, who has been, perhaps, more successful than any other in effecting a scientific organization of what Mill calls the rubble heap of economic and commercial geography, has accomplished the task on the basis of natural economic regions. A hopeful solution of our fundamental problem has already been reached.

Structure and Relief as Dominant Factors in Subordinate Regions.—It remains to inquire what part the so-called physiographic or crustal features play in determining the economic character of a natural region. A map of physiographic regions based on surface form and internal structure bears the same relation to the complete geographic unit as an anatomical chart of the human body bears to the character and personality of man. This comparison is not used to belittle the importance of those factors. In a large sense the relief of the earth's crust determines the position, area, and outline of the land masses and oceans, and thus furnishes the substratum without which there could be no such problem as we are discussing. Relief acts indirectly through its effect on climate, and that not so much in its control of temperature as in its effect on rainfall. The American Cordilleras stretch a belt of temperate to cold climate across the zones from Alaska to Cape Horn, but they also determine the humid and arid regions of two continents. The Central African plateau may prove a more valuable economic asset than the Amazon plain because it is cooler and drier. Relief exerts a general control of drainage, and determines the availability of streams for navigation, irrigation, and water power. It renders transportation easy or difficult, and this influences trade. It is a prime factor in determining accessibility and arability. Among the factors of crust structure the most widely important is soil, because of its influence on vegetation and agriculture. To structure

also belong mineral resources, such as coal and iron ore, which superpose upon conditions of normal agriculture an industrial economy, as in the Pittsburgh-Cleveland district. This influence may become dominant, as in England and Belgium. The mining of gold, silver, diamonds, and other minerals induces an intense and peculiar economic condition, which is local and often temporary. Petroleum and natural gas are economic intoxicants, and demoralize a community like an alcoholic spree. It seems to me that in the final solution of our problem, structure and relief will afford the best basis for the division of large natural provinces into subordinate regions. The United States belongs to five or six natural economic provinces. In some instances their boundaries coincide with physiographic lines, but each province includes several or many of the physiographic regions of Powell or Fenneman. The northeastern part, with portions of Canada, constitutes one province characterized by a warm, moist, growing season, rainfall between twenty and sixty inches, coniferous and summer forest and prairie, cereal agriculture, hardy fruit-growing, swine and cattle feeding, dairying, coal, iron, timber, and manufactures, all tied together by waterways and railroads. This large area is divided by the Appalachian highland, coastal plain, glacial drift plain, and other pedographic features into subordinate regions, each of which displays minor variations from the general condition of the province. Each region may be subdivided into smaller districts *ad libitum.*

Varying Importance of Influencing Factors.—Within the wide limits of a natural province, the economic character of a region may be controlled by one dominant factor or another, mineral resources, disturbed structure, dissected topography, steepness of slopes, glacial drift, indented coast, navigable rivers, alluvial soil, or what not. In such cases the dominant factor should be recognized and given due weight. Within the West European Province of oceanic climate, Great Britain may be treated as a continental island plus coal, the Netherlands as a deltaic land, and the Alps as a high mountain land. Among Mediterranean lands, Italy is distinguished by its peninsular, as Spain is by its continental, character. The Nile stretches a slender thread of irrigated land across the Sahara.

"The recognition," says Herbertson, "of the fact that we can divide the earth's surface into natural regions which can be classified into types is for the moment more important than the question whether the best natural regions have been selected. No doubt with better knowledge, better divisions, certainly more minute divisions, will be made."[1] It is only by the persistent study and systematic development of regional geography that we may hope to understand the world-wide complex of land, water, air, plant, animal, and man.

Summary.—1. In any region on the crustal surface of the earth the solid, liquid, gaseous, plant, and animal factors fit into one another with

[1] *Scientia*, XIV, 210.

a workable and livable adaptation, forming a physical and biological complex which constitutes the natural environment of man.

2. Human culture is more or less inherited, imported, and discordant; but in all stages of culture, human economy is as closely related to the natural environment as are the biological factors. Economic function, therefore, furnishes a standard for estimating the geographic value of the various factors which make up a natural complex, and a guide for the delimitation and classification of natural regions.

3. In a natural economic complex climate and vegetation exercise a controlling influence.

4. Structure and relief not only modify climate and vegetation, but also introduce independent and sometimes dominant factors in subordinate regions.

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THE CONFERENCE ON THE DELINEATION OF PHYSIOGRAPHIC PROVINCES IN THE UNITED STATES

F. E. MATTHES

CONTENTS

Origin of the Conference.—In connection with the Chicago meeting of the Association of American Geographers in 1914, there was held a "round table" conference, the purpose of which was to afford opportunity for a free discussion of the problems involved in the division of the area of the United States into physiographic provinces, with a special view to ascertaining whether collaboration in that work by a number of geographers under the leadership of a committee of the Association might prove advisable and practicable. At the Princeton meeting in 1913, the need of closer agreement among American geographers as to the physiographic subdivisions of the United States had been brought out by Professor Nevin M. Fenneman in a paper entitled "Physiographic Boundaries within the United States."[1] As stated by him, these lines were at first roughly sketched, but not defined, and, as a result, geographers and geologists in using them have frequently been inconsistent. "A quadrangle, county, or half a state is assigned by one worker to one province, and by another to another province, and when examined in detail, the formerly sketched lines may be found to cut through the middle of broad areas of uniform character."

At the same meeting, it so happened, Mr. Wolfgang L. G. Joerg presented a brief review entitled "The Subdivision of North America into Natural Regions,"[2] in which the lack of harmony among the geographers, American and European, who have attempted to partition the North American continent into its various subdivisions, orographic, physiographic, climatic, phytogeographic, zoögeographic, and its "natural regions," was made manifest. The simultaneous production of these two papers seemed itself indicative of the needs of the time and prompted the suggestion which found expression in the meeting, that an effort be made to secure the co-operation of all American geographers interested in establishing, if possible, a scheme of physiographic subdivisions of the United States that would be found acceptable as a common standard in

[1] *Ann. Assoc. Amer. Geogr.*, IV, 84–134.

[2] *Ibid.*, IV, 55–83.

future research. It was in order that this plan might be submitted to a general debate that the "round table" conference was called.

Character and Scope of Work Contemplated.—The meeting was presided over by Professor Fenneman, who opened the debate by briefly restating the salient features of his paper. The point that seemed to be of prime importance at the outset was whether a map of strictly physiographic subdivisions could be made to serve the purposes of the regional geographer as well as of the physiographer. It was believed by some that a composite map could be made which would serve the purposes of both, and which would bear the same relation to a strictly physiographic map as it would to charts of climatic elements, life-zones, and realms. In the course of the discussion, however, it became increasingly clear that such a composite map would not well serve the physiographer's purpose, while, on the other hand, a map composed of purely physiographic elements would not embody the data required by the student of regional geography. What the latter requires is indeed a composite map in which the three elements, relief, climate, and vegetation are combined, a map showing units which are homogeneous in the true geographic sense, in which the environmental factors are essentially uniform throughout; for it is subdivisions of this kind—the "natural regions" of Herbertson, the *geographische Landschaften* of the German school—that are recognizedly the logical units of regional investigation. Nor do such geographic unit areas necessarily coincide in extent with physiographic provinces; some do, but others do not. Again, as has been pointed out by Passarge, in regional geography surface configuration often counts as a factor regardless of its physiographic significance, and mere orographic boundaries, in such cases, are likely to be of greater value than strictly geomorphologic boundaries.

The first part of the discussion thus served to clarify ideas as to the scope of the work contemplated; and it was seen that a map of physiographic provinces is primarily a physiographer's tool, the making of which had best be intrusted to physiographers; similarly, that maps of orographic subdivisions, climatic provinces, soils, phytogeographic and zoögeographic zones, in fact, all maps in whose composition there enters but a single geographic element, fall into the same category, each supplying the needs of a certain branch of geography, and requiring for its construction the special knowledge of the investigators in that field. On the other hand, it was recognized that a map of natural regions would be a work of a different and higher order, inherently synthetic in its nature, that would demand geographic knowledge of the broadest sort, and therefore had best be undertaken by the men who are to use it, namely, by those carrying on research in regional geography and anthropogeography.

Problems of Physiographic Subdivision; Recommendation of the Conference.—The remainder of the session, accordingly, was devoted to a more intimate consideration of the problems involved in the division of the area of the United States into physiographic units. A

number of topics were touched upon, such as the proper basis of subdivision—whether to be found in unity of topography, structure, or physiographic history; the size, rank, or order of magnitude of provinces and their subdivisions; the character of the boundaries, their diversity, their frequent vagueness, the best mode of representing them on the map. In order that the discussion might profit from the consideration of concrete cases, a start was made on a partition of the North American continent into its primary divisions. None of the questions at issue were definitely settled—nor was it the object of the conference to undertake to settle them; but the nature and spirit of the discussions, and the general feeling of harmony that prevailed in spite of divergencies of opinion, seemed to hold sufficient assurance to those present of an agreement being obtainable on each point. The advisability and practicability of carrying on the work in concert, in accordance with the plan proposed, therefore seemed no longer questionable, and the conference ended with the passing of a resolution recommending to the Council of the Association the appointment of a committee to undertake the preparation of a physiographic map of the United States with the co-operation of all American geographers and geographic institutions interested in that work.

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Volume V, pp. 131-133.

MEMOIR OF WILLIAM W. ROCKHILL

WILLIAM CHURCHILL

Within limits of the brevity which must necessarily be observed in such a memorial as this, it is impossible to write to scale of the accomplishments of William W. Rockhill. His culture was of the sort to be measured rather than described; he was full dimensional; we think of him in terms of mathematical co-ordinates, for these alone can give us the picture of the length of his research, the breadth of his intellectual compass, the depth of his comprehension. Recognizing the impossibility of presenting here an adequate picture, I prefer to sketch in a few lines some two or three illustrative incidents which at decade intervals served to establish my intimate mental image of Mr. Rockhill.

In the early nineties I was called in by Professor Otis Tufton Mason to assist in the installation in the National Museum of the ethnical collections of the Wilkes Expedition, then just recovered from a half-century's disappearance. It happened that at the same time Mr. Rockhill was engaged in installing his collections from China, objects of the richest art of modern times, so far as there can be said to be anything modern in that most ancient empire; priceless relics of a past which elsewhere than in the Middle Kingdom would be prehistoric. His were the treasures of the ripest art; his project of installation in display cases summoned the most complete resources of his culture and the fullest artistic sympathy. Mine were but the crudities of stone and shell and wooden billets which primordial savages had but just begun to shape to their daily needs and in which art treatment was no more than the faintest foreshadowing of what it would take long ages to bring to pass. Yet in this task I found Mr. Rockhill a volunteer collaborator of inestimable value. He gladly turned from his own task to give me the benefit of his advice. He was as keen as I could be in seeking to decipher the mildewed and almost effaced labels on these bits of wood and stone. He displayed an acquaintance with the cultural development of these savages of the South Sea which transcended that of many special students of Polynesian ethnology. If those collections of the Wilkes Expedition possess any value in the system of their present assembly at the National Museum, the credit is due to the assistance which Mr. Rockhill gave without measure when we were engaged upon the difficult task of bringing the material into order.

Some years later I was summoned to administer the affairs of the kingdom of Samoa in a diplomatic capacity. The Samoans were then in an almost overwhelming revolution against King Malietoa Laupepa, and of the partners of the United States in the Berlin General Act, under which we

were maintaining that feeble little kindgom, Great Britain and the German Empire were manipulating events toward the ultimate annexation of those very important islands. The situation which opened before me was one of extreme difficulty and the most minute complication. From the State Department I received the most careful instructions as to conduct in every foreseen emergency, for at Apia I should be wholly out of the world of communication and should be required to act long before I could refer the difficulties to Washington. Here again I was brought into the most intimate and confidential contact with Mr. Rockhill, the best authority in the State Department on the great international problems involved, and already weighed by the professional makers of world policies in the foreign chancelleries as one of the greatest and soundest of the diplomats of the world. That he was able to advise me sagely as to the problems of the Berlin General Act touching upon the interrelations of the three great powers which maintained the condominium was merely a mark of his great skill in diplomacy; that he was able to advise with no less sageness upon the small policies of this puny race of savages illustrated the depth and completeness of his knowledge of human nature.

My last association with Mr. Rockhill touches tangentially or in a brief secant upon one of the most remarkable triumphs of American diplomacy, the accomplishment of a stroke of the most extremely important negotiation which could never have been led to completion except through his offices, a negotiation which had never been attempted by any of the Christian nations in their relations with the Sublime Porte.

At the beginning of the present administration my colleague, Colonel John Park Finley, was in Washington seeking the accomplishment of a most difficult and interesting mission. He had just completed service of eleven years as governor of the Zamboanga province in southern Mindanao, the paternal ruler of a population wholly Muhammadan. He carried with him credentials from the Moro dattos establishing him as special envoy to the head of their faith. The object of the mission was most important, in that the purpose of their inquiry was to know if the Sultan would set the seal of religious approval upon their accepting the sovereignty of the United States. It was the key to peace with our savage wards; it would do more than armed hosts to bring order in the wilds of the southern Philippines. Mr. Rockhill was then ambassador at Constantinople, accredited politically to the Sublime Porte as a civil state. Upon him fell the difficult task of opening the Sublime Porte as a religious approach whereby a Christian envoy, not of a Christian state, but of Muhammadan religionists, might present the religious plea to the Commander of the Faithful whose results were in turn to find their effectual completion in the amelioration of civic conditions. In all the centuries of frequently difficult intercourse of western nations with the Sublime Porte there existed no precedents for such a mission. The great Muhammadan empires of Britain and France had never ventured to seek access to the

Sultan as head of one of the great religions of the world. The situation was enormously complicated; Mr. Rockhill had to establish new lines of approach in the always dangerous field where religious convictions might at any time flame out into zeal which in less scrupulous guidance was likely to blaze out as fanaticism. He succeeded. Colonel Finley was led to the Sultan as a religious envoy of the Moro peoples, and only as a subsisting and neglected condition was he noticed as a citizen of the United States without representative quality save as representing the Moros. As Commander of the Faithful the Sultan, sitting in the Sublime Porte, issued to his religious subjects the first guaranty of a Christian nation ever given, a new and great fact in history. It is more than doubtful if any other could thus have forwarded Colonel Finley's Moro mission; at least it is indisputable that no envoy of a Christian nation had ever established relations with the head of Muhammadanism. It is one of the most brilliant records of American diplomacy; it was the crowning triumph of the career of a man who was great in every relation of life.

In these brief notes I have not pretended to touch on more than one point of the many-faceted character of the Rockhill with whom I was brought into intimate contact. The incidents are discrete, widely separated in time and subject, and wholly personal. Yet they unite; they are three expressions of the same thread of Mr. Rockhill's nature; they shed tiny beams upon that principle which actuated him in all the relations of a full and well-rounded life. His intensely vivid humanity found its choicest, yet most common, expression in the zest of intimate sympathy and the joy of giving himself wholly in service.

TITLES AND ABSTRACTS OF PAPERS

Chicago, 1914

Presidential Address—Albert Perry Brigham

Problems of Geographic Influence.—Printed in full herewith (pp. 3–25)

Rollin D. Salisbury

Porto Rico

Walter S. Tower

Some Geographic Factors Influencing Brazilian Trade

Brazilian trade development has differed from that of most other South American countries. In colonial times and later the value of Brazilian trade generally exceeded that of any of its neighbors, and trade from Brazil to the United States has been nearly as large as from all the rest of the continent. Lately Brazil has faced severe commercial crises. Location, topography, climate, and character and distribution of natural resources are some of the geographic factors which have influenced its trade development.

Henry Allan Gleason

Postglacial Migrations of Vegetation in the Middle West.—Read by Title

After the retreat of the Wisconsin ice-sheet, the following periods may be traced in the development of the vegetation of the Middle West:

1. The northward migration across the region of the arctic and boreal floras, which now reach their southern limits, with some exceptions, in Central Wisconsin and Central Michigan.

2. A xerothermic period, during which the vegetation of the Prairie Province migrated eastward, and occupied the southern third of Wisconsin and Michigan, the northern half of Indiana, and an extensive area in Ohio.

3. A period of climatic amelioration, during which the forests of the Central Hardwood Province migrated northwestward, displacing most of the prairies in Ohio and Michigan, and making considerable progress in Indiana, Illinois, and Wisconsin.

4. A period of prairie fires, following the advent of man, during which the advance of the forest was checked. In many places the prairies again began to enlarge.

5. A period of civilization, during which many areas formerly prairie have grown up to forest.

6. The present period, during which native vegetation is being displaced by cultivation.

Probably at least three-fourths of postglacial time belongs to the first three periods. The fifth and sixth occupy the last century only.

N. M. Fenneman

Bases for Dividing the United States into Physiographic Provinces

An introductory consideration of the questions to be discussed at the Round Table conference on the evening of December 29. What should be the scope and purpose of a map of physiographic provinces? What should be its relation to a map of "major natural regions"? Can provinces distinguished on the basis of physiographic history serve the purposes of geographers who are concerned primarily with human affairs, or must there be separate physiographic maps for these two purposes? To what extent can the physiographic divisions of a continent be classified and co-ordinated? If this is attempted, what shall be the basis of co-ordination?

G. E. Condra

The Loesses of Nebraska

There has been much contention concerning the origin of loess. The discussion has been general. This paper will describe four loess deposits, giving their origin, distribution, topography, and significance in geography.

Mary J. Lanier (Introduced by R. D. Salisbury)

West Indian Trade as a Factor in the Early Development of Certain New England Ports.—Read by Title

Geographic conditions made maritime interests predominant in colonial New England.

The West Indian trade, the most profitable to New England, was favored by geographic conditions and its character was shaped largely by them. This trade was carried on, not only with the British islands, but with the Spanish, Dutch, and especially the French, colonies.

Superior harbors, a more advantageous location for trade, and access to better timber supplies for shipbuilding favored the concentration of trade in certain ports of Eastern Massachusetts and of Rhode Island. In the early development of these ports no single influence was so significant as the trade with the West Indies. Interference with this trade contributed largely to the dissatisfaction which finally led to the Revolution.

F. E. Williams (Introduced by Lawrence Martin)

Some Influences of the Great Lakes on the Development of Wisconsin

The Great Lakes have been important as a highway for the use of Indian, Frenchman, Englishman, and American. As a result of this easy

route to the West, Wisconsin was explored earlier than the states to the south. Lake Michigan for a time acted as a barrier to rapid movement into Wisconsin, but after the development of steamboat traffic the Great Lakes became a highway over which many settlers came, over which freight, implements, and provisions were transported, and over which products were sent to the East, thus cheapening the food and fuel supply of the state and providing an outlet for the output of forests and mines.

R. H. Whitbeck

The St. Lawrence and Its Part in the Making of Canada

Eliot Blackwelder

Origin and Development of the Rocky Mountains in the United States

The mountain system extending from New Mexico northward to Montana owes its present structure and topography to certain distinct events in its past history. Its foundation material was prepared during an Archean (?) cycle of igneous intrusion with metamorphism, and an Algonkian-Paleozoic-Mesozoic eon of scarcely interrupted sedimentary deposition. At the close of the Cretaceous period its major structural features, such as folds and overthrusts, were impressed upon it, and some of its most important igneous intrusions originated at that time. During the early part of the Tertiary period the original structural mountains were almost entirely demolished and their stubs largely buried beneath continental sediments with copious, although local, volcanic ejecta. In the midst of the Tertiary period the region suffered notable warping, attended by some fracturing, especially along the western side. This episode terminated the period of continental deposition and in large measure the volcanic eruptions. It inaugurated a cycle of erosion which was permitted to go on to the stage of old age. Eventually successive continental uplifts on a grand scale and with but little warping induced the dissection of this aged surface. The existing topographic features of the Rocky Mountains are due almost exclusively to differential erosion at this time. Additional effects have been produced by three or more generations of local alpine glaciers, and by the pervasive but less obvious activity of the wind and other agencies. There remain very few constructional topographic features, either volcanic or diastrophic.

Mark Jefferson

The Gulf Stream.—Read by Title

Considers the problem of the portion of the Atlantic to which this name is to be applied, the nature of the Gulf Stream, and its effect on the climate of Europe, with personal observations from Cuba to Norway.

Collier Cobb

The German Interaction with Environment in Middle North Carolina.—Read by Title

In the birthplace of her citizens the most American state in the Union, and in the origins of her peoples the most British on the continent, the industrial development of up-country Carolina, from the early smelting of iron to the development of modern woodworking industries and the establishment of co-operative dairies, has been almost wholly the work of the early German colonists from the Rhine Valley, from Essen, from the Palatinate, and from Pennsylvania and the Valley of Virginia (the immigration being at intervals throughout the eighteenth century), and of their descendants. The paper traces these influences, and the modification of the German types and names.

J. Paul Goode

A New Series of Wall Maps for Schools

The requisites for school wall maps are discussed, and maps exhibited to show how the various problems have been solved, which have arisen in the making of this series.

Eugene Van Cleef (Introduced by A. P. Brigham)

Geography and the Business Man

Geography in the schools probably never has enjoyed the wholesome respect of the business man. Yet this man is in reality not averse to it. The geographic knowledge of his employees not always has satisfied him; logically he has attributed the deficiency to the school training. On the other hand, he probably never has stopped to inquire into the status of geography in the schools.

It is not difficult to convert the business man if you can show him "value received." That geography is a school subject that may bring returns cannot be doubted. It seems possible that it may establish itself much more firmly than ever through the medium of the business man.

N. A. Bengston (Introduced by G. E. Condra)

The Influence of Transcontinental Highways on the Price of Wheat

Wallace W. Atwood and Kirtley F. Mather

The Grand Canyon of the Gunnison River

The canyon of the Gunnison is cut nearly 3,000 feet into a fault block of Pre-Cambrian granitic rocks at the north base of the San Juan Mountains. The ancestral stream flowed over a gentle gradient on a peneplain surface developed upon extensive lava flows of mid-Tertiary age. Remnants of these flows now appear on either rim of the canyon. The present stream was superimposed upon the granitic mass. The canyon cutting

was not far advanced when the stream was blocked near the Vernal Mesa by ice from the San Juan Mountains. The ice belonged to the earliest of the three known Pleistocene epochs in those mountains. While the Gunnison was blocked, heavy deposits of gravel accumulated upstream from Vernal Mesa.

Since the retreat of that early ice the greater part of the present canyon has been cut, and in the neighboring regions to the southwest and north streams working on softer rocks have lowered the land surfaces below the level of the stream bed in the canyon. The great gorges and the broad, open valleys of this portion of Colorado have been largely developed during and since Pleistocene time. The higher relative elevation of the Gunnison River in its canyon made possible the great Uncompahgre irrigation project. A tunnel was driven through the southwest canyon wall and a portion of the water of the Gunnison is diverted by way of this tunnel to bench lands of the Uncompahgre Valley, where many thousand acres are being irrigated.

M. R. Gilmore (Introduced by G. E. Condra)
Some Indian Place-Names of Nebraska

Charles R. Dryer
Natural Economic Regions.—Printed in full herewith (pp. 121–125)

Robert M. Brown
Limitations of Water Transportation in the United States.—Read by Title

Our waterway problem has not become a national question, in reality, and this has been largely the fault of the experts who have not been able to present either a consistent policy or an opinion approaching unanimity.

This paper is an attempt to draw up a minimum demand, based on geographic conditions solely, which might be used as a foundation of our waterway policy. The treatment is based, first, on the distribution of population, second, on the movement of commodities, and third, on the development of markets and depots.

Wellington D. Jones (Introduced by R. D. Salisbury)
Geography of Northern Patagonia

Disadvantage of position and the handicaps of aridity, scarcity of navigable rivers, and the Andean barrier at the west explain the small amount of exploration and settlement and the scanty development of industries in Northern Patagonia. Along the 41st parallel of latitude there are three geographic provinces: (1) the 60–100-kilometer-wide Andean Mountain zone, with a heavy rainfall and a dense forest cover up to 1,400 meters; (2) the 500-kilometer-wide stretch of plains and low plateaus, arid to semiarid, with a scanty bush and grass vegetation; and

(3) the 20–50-kilometer-wide transition zone between, with a moderate rainfall and a vegetation in some places of grass, in others of forest. Grazing of cattle, farming, logging and lumbering, and the tourist trade are the industries which can be carried on in the humid province; grazing of sheep and farming by irrigation are possible in the arid and semiarid regions; grazing of sheep and cattle, farming with and without irrigation, and certain manufacturing industries which will use hydro-electric power generated in the Andes, all will become important in the transition zone.

Mark Jefferson

Regional Characters in the Growth of American Cities

The details in the growth of our cities reveal an intimate relation to their environment. Thirty-four cities of the humid East show *vigorous* growth, adding larger numbers to their population with each decade. Cleveland and Columbus are fine types. Their platted curves are concave upward. The river cities of the humid East after early vigor show *halting* growth, as the railroads superseded river transportation. Cincinnati is the type, with curve distinctly convex upward. There are six such, and the Great Lakes cities show symptoms of the same disease since 1880.

When the transcontinental railways opened the Pacific Coast to the American people, who were adventurous and well equipped with material resources, there resulted an *exuberant* growth of the cities of the new West, doubling their population for two decades running. In this group are eight cities.

How little the political function helps a city is seen by the sorry figure cut by Albany as a growing organism. Every city of 100,000 in the country has long outstripped it. Washington, though earlier vigorous, shows distinct signs of atrophy since its disfranchisement.

Ellen Churchill Semple

Influences of Geographic Conditions upon Ancient Mediterranean Agriculture

Dora Keen (Introduced by H. G. Bryant)

First Exploration of Some Alaskan Glaciers; Glaciers of Mount Blackburn, and the Harvard Glacier; Observations of Glaciers of College Fjord, Harriman Fjord, and Columbia Bay

1. *First ascent of Mount Blackburn,* 16,140 feet, Wrangell Mountains, by way of Kennicott Glacier, 35 miles long. An ascent never attempted before or since. Difficult and dangerous, because entirely above timber and perpetually on glaciers, with constant snowslides and concealed crevasses. Only the second successful ascent in Alaska, and the first with dogs and without Swiss guides. Required two expeditions of 13 and 33 days respectively, 1911 and 1912.

2. *First exploration of Harvard Glacier*, 18 miles long, at head of College Fjord, Prince William Sound. Glacier difficult of approach because of dangerous tidal cliff, surface too rough for travel for miles, and many tributaries of like nature. No timber. One month to reach sources, at 6,100 feet, 16 miles from face. No pass found, but topographic notes and views secured for first map of this part of Chugach Mountains. Also observations, as on Mount Blackburn, of temperatures and snowfall, throwing light on alimentation of glaciers. August and September, 1914.

3. *Observations and photographs of glaciers of Prince William Sound.*—Continuation of work of Harriman Expedition, and of expeditions of United States Geological Survey and National Geographic Society, in College Fjord, Harriman Fjord, and Columbia Bay. Twenty-five glaciers observed, from stations occupied by former expeditions, thus showing changes in advance or shrinkage of glaciers. September, 1914.

W. E. Lingelbach (Introduced by G. B. Roorbach)
Geographic Factors in Russian History

Frank Carney
Human Relations in the Glacial Lake Plains of Ohio

The simple trails of the Indians followed the beaches which now carry the improved highways of modern agriculturalists. Terraced into five or six steps, the bordering lake plains, with their highly fertile and confusedly diversified soils, rank among the richest and most conveniently cultivated farming regions of North America.

Primary and secondary glacial clays on the surface, and easily mined shales, abundantly outcropping lime and sand rocks, sand, gravel, gas, and petroleum, more than meet the local demands for brick and tile, lime and cement, building and abrasive stones, foundry sand, concrete, and fuel. Hydro-electric energy is made available by the numerous streams.

In response to the favorable location of this region in reference to markets and sources of various raw materials, its industries, in the value of their business, already rival the marvelous income from its farms.

Robert DeC. Ward
The War and the Weather.—Read by Title

War and the weather are closely related. All through history, weather conditions have played a decisive part, not only in individual battles, but in whole campaigns. The present war has furnished many examples of the control which meteorological conditions have had upon military tactics, naval strategy, and aviation. The study of these cases is not only interesting in itself, but at the same time helps toward a better understanding of European climates by emphasizing the human relations of these climates. It is as important to know what weather conditions are

likely to be met with during a campaign as it is to know the topography of the war zone.

Lawrence Martin

Studies in Military and Naval Geography.—Read by Title

Studies in strategic geography in connection with (*a*) the German campaign in France and Belgium, (*b*) the Russian campaign in Germany and Austria, (*c*) the Turkish campaigns in Armenia and Caucasus and near the Suez Canal, (*d*) the campaigns in the Balkan states, (*e*) naval warfare on the seas surrounding Europe, and (*f*) the war in the colonies and on the Atlantic, Pacific, and Indian oceans.

V. C. Finch (Introduced by Lawrence Martin)

Some Geographic Factors in the Distribution of Agricultural Products in Europe

Some economic and geographic relationships appearing in a series of detailed crop maps of Europe. Among the more apparent of these relationships is the complementary distribution of the wheat and rye crops, or of the corn and sugar-beet crops. Similarly the abundance of cattle on the west coasts, their sparsity along the Mediterranean, and the corresponding abundance of sheep and goats in the latter region reflect the rainfall and pasturage conditions.

The series of maps is of particular interest in connection with the present European food situation.

O. D. von Engeln (Introduced by A. P. Brigham)

The Interpretative and Constructive Value of Authentic Instances of Geographic Control, Illustrated by a Specific Case

Geologic, economic, and historic factors, as well as purely geographic conditions, usually need to be taken into account in attempting to explain the features of the earth in terms of their relations to, and influence on, life forms, particularly man, and it is this complexity that makes difficult a correct interpretation. In view of these facts it seems that there has been shown a too-great zest in geographic writings for such deductions as admit of wide application, and a too-eager search for *latent* geographic influences, with consequent neglect of the obvious.

It is the purpose of this paper to point out (*a*) that broad generalizations are likely to be unsafely applied; (*b*) that if geographic influences are effective they must primarily exercise control over individual enterprises and only ultimately affect the community; (*c*) that if geographic conditions can be shown to have influenced the success of particular enterprises it ought to be possible to suggest other opportunities with similar advantageous geographic features, and thus give geography a practical and constructive value; (*d*) that such studies, contributed to the literature of geography, would be particularly worth while if regional in type so that

in time material would be available for a systematic, geographic description of the whole of North America.

The geographic conditions affecting the Portland cement industry of south-central New York are here cited in illustration of the nature of such a study. In modern industry environmental control tends to disappear as the product decreases in bulk and increases in value. The transportation factor is probably of first importance as a determinant of the degree of success of an enterprise involving the use of bulky raw materials or bulky finished product. Hence, if it can be shown that geographic conditions minimize such costs in a particular instance of this nature, we have a specific example of geographic control. That such costs are of especial significance in the cement industry is indicated by the fact that cement manufacture requires as much capitalization per ton of product as does pig iron, but the iron has three to four times the value of the cement. Moreover, increased use of cement has made possible large-scale production and maximum industrial efficiency in the industry. Hence, a comparatively small plant remote from large markets seems very clearly to owe its existence to geographic advantage.

In south-central New York the Tully limestone, of composition suitable for cement manufacture, outcrops along the shores of the two larger Finger Lakes, Cayuga and Seneca. At a point on the east side of Cayuga Lake and near its southern end the Tully develops an anticline; this has topographic expression as a local elevation marked by a steeper slope along the lake shore, making practical the aerial-tramway conveyance of rock from the quarry face to the mill at lake level. Weathered rock material above the limestone was nearly all removed by glacial erosion, and only a little till was deposited over it—hence no costly stripping of overburden is necessary. Below the limestone is the Hamilton shale; the small amount of this needed for cement mixture is available as desired. Stream and glacial erosion has sectioned the anticline along the line of the lake trough, making the outcrop, and has furnished a water-transportation route via barge canal to large population centers. Delta building of a small stream flowing down the lake shore slope has provided a millsite. Terrace cutting and building by wave work has provided a water-level railroad route along the lake shore. As a result of this combination of conditions all moving of the large-bulk materials of the industry may be performed at a minimum cost.

While not of exactly the same nature, similarly favorable geographic sites for other cement plants could be pointed out on the line of the outcrop of the Tully on the western side of Cayuga Lake and on both sides of Seneca Lake. Ability to suggest such opportunities gives a practical and constructive value to geographic study. A broader study of like nature of any given region would afford a vivid notion of its possibilities, and a multiplication of such studies would furnish eventually a comprehensive and fruitful geographic survey of the whole continent.

Richard E. Dodge

The Influences of Invention on the Distribution of Types of Dairying

The contrast between modern and earlier types of eastern dairy farming in the effects on production, on the seasonal distribution of labor, and in relation to markets; the significance of the silo in the distribution of winter dairying and in the distribution of corn cultivation; the importance of standardized machines and machine parts in agriculture; the relation of dairying to the technical details of wheat-milling; some recent suggestive experiments.

Sumner W. Cushing

The Geographic Content of the Census of India for 1911 (Published in 1914).—Read by Title

The census of India is remarkable for a standard of accuracy probably not attained elsewhere, for the comprehensiveness of the data collected, for the exhaustive analyses, and for its interesting, informing, and authoritative deductions. Geographical data have a large share in the treatment, although not so large as geographers would wish. This paper discusses the natural divisions of India, distribution and movement of population, and distribution of religion, language, infirmities, occupations, and customs. Comparisons are made with the census of 1901.

E. F. Bean (Introduced by Lawrence Martin)

Methods of Mapping Glacial Geology in Northern Wisconsin

In a region where many townships have few or no settlers, where roads are few, where no topographic maps and few maps of any sort are available, methods of work are necessarily quite different from those employed in a better-settled region. During the summers of 1913 and 1914 the Wisconsin Geological Survey mapped about 3,200 square miles in Northern Wisconsin. Throughout the area paced traverses, made at half-mile intervals from known corners, furnished the necessary location for mapping the glacial geology. Such difficulties as swamps, slashings, and growth of vegetation added to the problems of the geologist.

Herbert E. Gregory

The Oasis of Tuba, Arizona.—Read by Title. Printed in full herewith (pp. 107–120)

Cyrus C. Adams

To Advance the Standards of Geographical Education in Our Country

Conditions which make it important that the Association of American Geographers should conduct investigations upon which to base work to this end.

Leon Dominian

Eurasian Waterways in Turkey.—Read by Title

The straits of the Dardanelles and of the Bosporus as well as the connecting sea of Marmora constitute points of nearest convergence between the continents of Europe and Asia. This circumstance of location has affected the political status of the region. The world-relation of the waterways has been far-reaching since early historical times. It embraces both the Eastern and Western Hemispheres.

Samuel Weidman

Economic Aspects of the Glaciation of Northern and Southern Wisconsin.—Read by Title

R. H. Whitbeck

The Differentiation of Races as a Geographic Problem.—Read by Title

F. E. Matthes

The Evolution of the Glacial Cirque

C. F. Brooks

The Snowfall of the Eastern United States

TITLES OF PAPERS

Joint Meetings of the Association of American Geographers and the American Geographical Society, New York, 1914, 1915

1914

L. A. Bauer
The General Magnetic Survey of the Earth

W. H. Hobbs
Land Sculpturing in Arid Lands with Observations from Northeastern Africa

T. Wayland Vaughan
The Platforms of Barrier Coral Reefs

D. W. Johnson
Botanical Phenomena and the Problem of Coastal Subsidence

E. W. Shaw
Characteristics of the Mississippi Delta in the Light of Comparative Studies of Some Old-World Deltas

Oliver L. Fassig
The Period of Safe Plant Growth in Maryland and Delaware

Frederick J. Turner
Geographic Influences in American Political History

J. Russell Smith
The Tree as a Factor in Man's Adjustment to Hilly and Rocky Land

W. W. Atwood
Over the San Juan Mountains to the Ancient Cliff Dwellings of the Mesa Verde

Collier Cobb
The Forest of Sunburst: A Study in Anthropo-Geography

1915

W. M. Davis
The Coast of New Caledonia

H. E. Gregory
Geography of the Navajo Country

Mark Jefferson
Utah, the Oasis at the Foot of the Wasatch

C. S. Scofield
The Geographic Factor in Agricultural Industries

N. H. Darton
Origin of Some Desert Basins

M. L. Fernald
The Natural History of Ancient Vinland, and Its Geographic Significance

George A. Plimpton
Early American Geography

Bailey Willis
Argentina and the Argentines

R. DeC. Ward
Winter Weather as a Factor in the Great War

Lawrence Martin
The Muir Glacier in 1911 and 1913

Explanation of Plate I

a. View in the Painted Desert, which forms a belt extending from the western border of Tuba Oasis to the Little Colorado Canyon. Its surface is formed of intricately carved and brilliantly colored rocks interspersed with areas of sand.

b. Traveling dunes near Reservoir Canyon.

Plate I

a

b

Explanation of Plate II

a. Wind-swept rocks along the northern border of Tuba Oasis.

b. Bare canyon wall with ancient cliff house at Honogee. (Photograph by Walter Runke.)

PLATE II

Annals of the Association of American Geographers, Volume V

a

b

Explanation of Plate III

a. View on the Tuba Oasis.

b. A portion of a canyon on Kaibito Plateau filled by wind-blown sand.

Plate III

a

b

Explanation of Plate IV

a. Fields in Moenkopi Wash reclaimed and cultivated by the Mormons.

b. Hopi cornfield at Moenkopi.

Plate IV

a

b

Explanation of Plate V

The Hopi Village of Moenkopi, built since about 1880 on the site of an ancient pueblo.

PLATE V

Annals of the Association of American Geographers, Volume V

INDEX

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CONTENTS

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SOME PROBLEMS IN GEOGRAPHIC EDUCATION WITH SPECIAL REFERENCE TO SECONDARY SCHOOLS[1]

RICHARD ELWOOD DODGE

It may seem at first superfluous to devote this address to the discussion of problems in geographic education when more than one-half the members of this Association are engaged in teaching geography, or some phases of the subject, in our higher institutions. Having, however, worked many years in the shadow of both geography and education—as it were, in the umbra of the one and the penumbra of the other subject—my energy has been devoted increasingly to the consideration of those problems which involve the effective coordination of educational theory, practice and ideals and the ideals of the professional geographer and the professional teacher of geography. I have realized more and more fully as the years have passed that we shall never have effective geography teaching until geographers and educators come to understand each other better, are more sympathetic each toward the other's viewpoint, until they realize that their ideals have many factors in common, and that effectiveness can be secured only by team work. The time has passed when in education, in sports or even in life, the star player can afford to sacrifice the success of the "team" to increase his vanity or promote his dignity.

Education is not today what it was twenty-five years ago. No longer are the best methods of teaching a given subject decided by show of hands in a class room or applause at a teachers' institute. A successful worker in education must follow those fundamental principles of his young science, that have been measured quantitatively or tested and proved by other experimental methods. The apprentice system, by which so many of us have come to our life work, cannot now be considered the best preparation for success in teaching any subject.

I remember but two pedagogical suggestions that came to me in my early years of teaching, both unconsciously given. They were both wise and helpful; both were founded on experience and a knowledge of human psychology, but both were in reference to the handling of people and not to the handling of the subject, so as to present it most effectively to freshmen—the task before me then.

I can see as though it were yesterday my master, Professor Shaler, —to give him the deserved title with which he always so reverentially

[1] Presidential Address delivered before the Association of American Geographers, Washington Meeting, December, 1915.

spoke of his master, Louis Agassiz,—as he sat behind his long table and listened to my request for advice as to how to handle my first problem in teaching—a student older than I who had protested about his mark. Taking his long pipe from his mouth in the characteristic manner that every old student of his remembers so clearly, Professor Shaler remarked, "I leave it entirely in your hands. Keep your temper." I recognize now that no advice could have been wiser or more helpful to meet the situation. It has helped me many times since, in dealing with youth as well as with adults. The second suggestion came from the master of geography in whose mind this Association was conceived and to whom we owe so much of our strength. During a conversation on a field trip over Hoosac Mountain, Professor Davis remarked, "Don't laugh *at* children, laugh with them,"—a rule I have found of great assistance in dealing with impressionable youth.

I have given these personal remembrances, not in the spirit of reminiscence which is a sign of advancing years; not to give credit to the two honored teachers whose influence has been most significant in my life—that would be impossible—but to indicate the character of the incidental apprentice training in teaching of the last century, that I may contrast with it certain aspects of what might be called the systematic shop management training in education of this century.

It is no longer believed that "teachers are born, not made." They must be born and made, trained in their subject, in methods of imparting it, and in the practice of educational principles, if they are to be successful from the start. Others may survive and succeed. By trial and error, by experiment and adaptation, using classes as unresisting but by no means willing laboratory material, ignorant of the relative values of possible methods of teaching a given subject, perhaps even ignorant that there is any other subject except their hobby, some may become teachers of worth, but many fall by the wayside, fortunately for the cause. Today few of us believe that we can be teachers of geography if we think only of presenting our favorite subject in a logical sequence and leave out of account the men and women, or youths and maids, on whose effective training to meet their life problems our success as teachers depends. Consciously or unconsciously we make use of some of the established theorems of educational psychology and of the proved principles of education.

The progress of the cooperating science of education within the last two decades has been so rapid, and it has so grown in strength and usefulness, that today few question its right to a place in the curriculum of the higher institutions of learning. This is more than can be said for geography, either for the secondary school, the normal school, or the college. There are some who even question the value of geography in elementary schools. Education as a subject is now generally recognized as necessary in the efficient training of teachers of any grade.

As is characteristic of the early stages of development of any movement, some have gone to extremes in their stressing of education. So much attention has sometimes been given to the theory and principles of education, that pupil teachers in training have not had sufficient time for proper preparation in the subject matter, which should be the basis of any training for teaching. Just as youthful Doctors of Philosophy in some narrow specialty have been imposing their lecture notes from the University and University methods of instruction, on the secondary schools, thereby augmenting the university influence that so long hampered secondary education, so teachers educationally overtrained, but with no adequate knowledge of geography, history, mathematics or English, have weakened rather than strengthened elementary education.

To be educationally top heavy is worse than to be geographically or historically top heavy; both are unfortunate in all phases of education, but especially in elementary, secondary and normal school work. As Geikie long ago expressed it, " In the teaching of geography, as in instruction of every kind, the fundamental condition for success is that the teacher has so thoroughly mastered the subject himself and takes so much interest in it, that he can speak to his pupils about it, not in the set phrases of a class book, but out of the fullness of his own knowledge, being quick to draw his most effective illustrations from the daily experiences of those to whom he addresses himself."

In other words, a knowledge of children's interests and of the best methods of making connections between the known and the unknown, the basis of modern educational practice, are both necessary. Today leading educators no longer hold the belief that students can, through education, be taught to teach what they do not know, nor that the person who has the most intimate knowledge of his subject is thereby of necessity a real teacher. Education has passed through the period of exploitation, and the period of being organized about the momentary ideals of magnetic and appealing leaders—so characteristic in the development of almost any subject, as it is of governmental policy—and is now a growing science, with certain fundamental principles that are no more questioned than is the fact of evolution.

The recent progress in education is indicated by the significant fact that twenty years ago our educational institutions were giving courses in educational theory, while today we find courses entitled the principles of education. Similarly child study has given way to educational psychology, whose far-reaching scientific conclusions have given us a basis for reorganizing our antiquated and unscientific class room methods. Progress in the education of an individual or a group, at least in the lower schools, is no longer estimated; it is *measured.* Standard tests are widely used to measure advancement in arithmetic,

in reading, in spelling, in writing, in composition and in drawing.[2] Schools can now be standardized as to the quantity and quality of their work, and individual methods of teaching can be compared in effectiveness, without impairing the spirit of the school work or weakening the significance of the personal touch that makes the real teacher. Methods of accurately measuring results in history, geography, literature and science—the so-called content subjects—are now being studied and doubtless will soon be available. Initial steps have already been taken to determine the minimum essentials of geography in the elementary schools,[3] which may form a basis on which may be constituted a fuller and more vital course in geography. So far attention has been given only to listing the isolated facts of geography any person should know and be able to use. Inasmuch as one may be a gazetteer of information and not be a geographer, or even educated in geography, it is sincerely to be hoped that the studies will be carried on until we have a minimum set of vital geographical relationships to supplement the jackstraw groups of facts, for the flesh and not the bones of our science is what gives it usefulness, form, beauty, strength and individuality. Any willingness on the part of educators or geographers to confine their attention to items of location, or of industrial products, can only result in strengthening the impression, unfortunately so general, that the content of geography is purely informational in character. Few geographers could subscribe to the following statement of the content of elementary school geography, copied from a recent prominent book on teaching, and to the implication as to the content of more advanced geography:

"A student knows his geography well when he knows the location of all the important places and products and can tell why these are where they are; and when he knows all the important geographical facts, as every person should by the time he finishes the geography course."

Such inadequate summaries, indicating a narrow perspective and a lack of knowledge of the real character of geography, hurt the cause of education, of geography and of education through geography. The

[2] B. R. Buckingham: Spelling Ability: Its Measurement and Distribution, *Teachers College Contributions to Education*, No. 59. E. L. Thorndike: Scale for Measuring Handwriting, *Teachers College Record*, March, 1910; The Measurement of Ability in Reading, *Teachers College Record*, September, 1914; The Measurement of Achievement in Drawing, *Teachers College Record*, November, 1913. M. B. Hillegas: Scale for Measurement of English Composition by Young People, *Teachers College Record*, September, 1912. Cliff Winfield Stone, Arithmetical Abilities and Some Factors Determining Them, *Teachers College Contributions to Education*, No. 19. H. B. Howell: A Fundamental Study in the Pedagogy of Arithmetic, Macmillan Co., 1914.

[3] W. C. Bagley: The Determination of Minimum Essentials in Elementary Geography and History, Chap. IX. Fourteenth Yearbook of the National Society for the Study of Education, University of Chicago Press, Chicago, 1915.

content, scope and possibilities of geography are primarily a question for geographers; the adaptability of certain phases of geography to pupils of a given age may be measured scientifically by trained educators; the best methods of teaching may be similarly tested, and we must accept and use the conclusions. This does not mean that we can subscribe to or must support every opinion published by a worker in education. We can accept his conclusions only when we can approve his methods of work as scientific and accurate.

Educational psychology in the hands of a few scientific workers has given us not only standards but a new understanding of the actual mental processes in adolescence, as well as in the earlier and later periods of learning. A study of the actual processes of learning by the experimental psychologists has proved that many of the older methods of teaching in elementary and secondary schools were inefficient because based on erroneous assumptions rather than on an understanding of the laws of habit formation. No longer is a teacher's ability judged by his power to keep pupils inactive physically, which sometimes means they are inactive mentally. The requirement is that he shall promote mental activity perhaps in part through physical activity, if thereby a pupil can best give expression to his ideas, or indicate the directions of approach to which he responds most naturally.

Our increasing knowledge of the actual processes of learning has required a reconsideration of some of the doctrines of education prominent only a few years ago. The report of the subcommittee on geography of the Committee of Ten, in 1893,[4] said: "While various activities of the mind are called into exercise in geographical work, the committee would advise that the systematic development of three classes of these should largely control the arrangement of the work, viz.: (1) the powers of observation; (2) the powers of scientific imagination, and (3) the powers of reasoning. The cultivation of the powers of observation is necessary to furnish clear, accurate and realistic fundamental ideas and modes of thought." This is an expression of faith in the doctrine of formal discipline, and differs but little from the appeals that have been put forth as to the moral and intellectual usefulness of every old subject whose value as a fundamental in education has been questioned, and of every new subject that enthusiasts would bring to the forefront in school curricula. The more difficult and remote a subject the better it was supposed to be for one's soul, because it gave "good mental discipline" and enabled one to prepare himself for other equally disagreeable tasks. "Aside from the psychological fallacy involved, that ability to do one kind of work would spread or be available for all other kinds of mental activity which we

[4] Report of the Committee on Secondary School Studies, p. 214. U. S. Bureau of Education, Document 205, Washington, D. C., 1893.

call by the same general name, the devotees of the doctrine ignored the fact that the maximum of activity or hard mental work could be secured only under the stimulus of genuine interest."[5]

Or, to put it in the words of Thorndike,[6] "It used to be thought, erroneously, that man's intellectual and moral responses were due in the main to a few formal abilities, such as attention, memory, imagination, reasoning, conscience, the will and the like, which worked in large measure irrespective of what particular stuff was to be attended to, remembered, reasoned about or chosen. * * * Intellect was not thought of as a multitude of special bonds between particular situations and particular responses, but as a few faculties and powers which could conduct certain operations equally well with almost any situation whatever. * * * As a result of the experiments that have been made since 1900, such expectations of universal transfer of ability in large amounts are no longer entertained by competent thinkers. It is agreed that there is no mysterious necessity in the nature of man which makes an improvement in grammatical reasoning spread to produce great improvement in all rational thought, or makes improved attentiveness to numbers in computation produce power to attend to the cloth in a loom or the marks on a butterfly. It is agreed that a gain in one ability improves others only in so far as it is proved to do so—that the question of the disciplinary value of any training is a question of fact to be measured, not an article of educational faith to be assumed. It is agreed that roughly we can hope for such wider improvement only in so far as the other abilities in question are in part identical with the ability specially trained. Investigations to ascertain just what these identities are, and just how far the improvement of certain abilities influences others, are among the most important now being made by scientific students of education."

Time will not permit any presentation of the experiments performed and tests made by the many workers who have contributed to the evolution of experimental psychology from a philosophy into a science. Suffice it to say that established principles of education, of which the new attitude of educational leaders toward the question of mental discipline is an instance, have brought about new and in general more efficient methods of teaching in our better elementary, secondary and normal schools. New methods involve not only a new attitude on the part of well-trained teachers, but new methods of class-room procedure, producing more initiative and responsiveness on the part of the pupils, of whatever age. The text-book is becoming a tool in education, and is no longer universally viewed as the final authoritative epitome of

[5] Strayer, George Drayton: A Brief Course in the Teaching Process, p. 235. New York, The Macmillan Company, 1911.

[6] Thorndike, Edward Lee: Education, p. 114. New York, The Macmillan Company, 1912.

wisdom on a given subject. Of course, as in any new movement, steps must often be retraced and a new start made. Enthusiasts who have caught the spirit of the new movement but who are still using its principles with unconscious quotation marks, may lead others astray and thus hinder the progress they would promote.

On the whole, however, progress is being made. The scientific leaders, the trained teachers of teachers, and the teachers trained from the new viewpoint, form a cooperating force for better teaching that is producing marked results. An examination of the course of study in any leading school system will indicate how modern education has given a new lease of life to the common school subjects and made them contributions to the real education of the future men and women. However much we may look askance at what seem to be the radical views of youth, and wish teaching were still what it was in the time of the desolate, unpainted "Little Red School House," we cannot afford to shroud ourselves in the cloak of conservatism, and continue to look backward into the vistas of experience, lightened only by the fading glow of youthful memories out of perspective.

We must look forward, and if we believe geography can be aroused from the state of arrested development in which it has so long lain dormant, we must join forces with all who can contribute scientific truth or accurately tested experience to the solving of the problems of such deep interest to all, and work for success as never before. Geography will come to its own when it is *proved* to be worth while in education. To make geography worth while we must not only scrutinize our methods of teaching from the educational standpoint, re-evaluate its parts, and perhaps the subject as a whole, but also pay attention to the educational movements that educational leaders, professional and political, are actively and effectively promoting.

Three movements of great significance, all vitally affecting the status of geography in elementary and secondary schools, have within the last few years come to the front in educational discussion and educational administration. They are the Junior High School, the adoption of General Science courses in the earlier high school years, and the project or the problem method of teaching, not only science, but other subjects.

Perhaps the most far-reaching and significant movement of recent years has been the development of the Junior High School which may be "defined as a special organization of grades 7 and 8, or 7, 8 and 9 to provide for greater differentiation of studies, better care of individual pupils, an easier transition to high school, longer school life, etc."[7]

[7] Report Commissioner of Education, Vol. I, p. 147. Government Printing Office, Washington, 1915.

By this system of organization some subjects, like mathematics beyond arithmetic, foreign languages, and commercial and industrial studies can be begun earlier in school life, the abrupt change in methods of school work customary where the high school follows after the eighth grade is avoided and children are kept interested in the work because content and methods change as their powers increase and ambitions develop with the on-coming of adolescence. Already reports of the success of Junior High Schools from many cities show statistically a great increase in the number of pupils that remain in school beyond the sixth or seventh grade. This division between the grade school and the high school which has so long remained untouched is disappearing like a mist before the breeze or sun.

How does this affect geography teaching in schools? Generally in one of two ways. Either continental or regional geography is dropped at the end of the sixth year of the elementary school or it is carried unchanged or modified into the first year of the Junior High School—the old seventh grade. If the former plan is followed the systematic study of geography that *everyone* may or might find useful is dropped just at the time when the increasing abilities of well-trained pupils make it possible for regional geography, whether taught by old methods or new, to be really a contribution to life preparation. In some schools geography in the Junior High School years is devoted to the elements of commercial and industrial geography, and no all-round regional study is given. Children are again "fed, clothed and sheltered" as they have been perhaps several times in the earlier years of school geography. Owing to the lack of good texts and equipment and to the inadequate training of the teachers, this work often becomes less serious and satisfying than the work it displaces.

Where regional geography is continued in the first year of the Junior High School, it is usually made somewhat commercial in flavor and fills a need that all recognize as worth while. At present the best work for Junior High Schools has yet to be found. The problem is before us and any consideration of science work, including geography, in secondary schools must take account of this movement and be organized accordingly.

General Science is a title that today looms large in educational discussion, and under it is included the work in science for the earlier years of the old type high school and the upper years of the newer Junior High School. Only six years ago a committee of the National Education Association[8] recommended a year course in geography for the first year of high schools, "about one-half to be devoted to the larger topics in physical geography, and that the remainder of the year be given to a study of North America and Europe." This recom-

[8] *Journal of Geography*, Vol. VIII, No. 1, September, 1909, pp. 1-9.

mendation varied but little from those of a report made to this Association in 1910.[9]

Since then General Science, or Elementary Science, has come in with a rush so impetuous that even its promoters have been swept from their feet and have found some difficulty in readjusting themselves. The effect has been in many cases to crowd geography from the curriculum.

The content of the course in General Science is generally determined, as is much of our work in elementary and secondary schools, by the available texts. Three types of courses are in vogue. One type includes selected items from astronomy, biology, physics, physical geography, etc., in no necessary order or sequence—a sort of idealistic kaleidoscopic offering that is sometimes more "general" or "elementary" than science. The second type consists of a course organized around physical geography, biology or physical science as a core, and includes special emphasis of the cross relations with other sciences, or parts thereof. By this plan of organization the unity of an individual science is minimized but not lost and the applications to life phenomena are brought out. The third type is more striking in that it involves cutting across all the sciences, ignoring the often meaningless classification of adults and organizing class work about selected experiences or phenomena that inquiring youth want to know about and which are worthy of systematic study. House sanitation, for instance, may involve topics from physics, chemistry, biology and geography.

This is an illustration of the third movement in education of widespread significance—the project and the problem methods of teaching. Anyone who has noticed the interest that boys take in the popular magazines devoted to the presentation of recent progress in applied science, and has used materials from them as an introduction to a knowledge of the scientific principles involved, believes in the project method of teaching for *his* boy, however strong his conviction may be that boys in general should follow the straight and narrow, and usually too steep paths of pure science. As one of the leading exponents of the "project method" of teaching General Science expresses it:[10] "Organization of subject matter must be around the knowledge of the pupil, not around that of the teacher or syllabus maker. In science, as in other subjects, much of the subject matter dealt with today by the subject-study method is of such a nature that in out-of-school hours and in after-school years it remains unused and so is forgotten. This is not true of the project method. The knowledge which is the boy's quest here is knowledge of which he sees the need. Being needed

[9] *Journal of Geography*, Vol. VIII, No. 7, March, 1910, pp. 159-163.

[10] John F. Woodhull: Science Teaching by Projects, *School Science and Mathematics*, Vol. 15, pp. 225-232.

and used, year by year, it will tend to be distinctly remembered. The project method in general science is more specialized than any portion of the college preparatory science, and like a dog pursuing a hare, it has a specific aim, albeit it jumps those useless boundary fences between the various fields of science." General Science, in other words, is a protest, based on psychological principles, against the unhumanized science that has worried pupils these many years in the earlier years of high school life.

The project method of selecting units for study may be and often is employed without breaking the old-time boundaries of the several sciences. Within each science, as for instance geography, problems of human or personal interest may be selected, the solution of which leads to an understanding of the principles and facts of geography that are ordinarily presented in text-books in a formal order. To quote from one of the more recent presentations of this method of study:[11] "A problematic situation, then, and not a recitation or a lecture demonstration or a laboratory exercise, should be the unit of instruction, excepting in the case of formal review lessons, and even the latter are better when thrown into problematic form. The aim of the student should be to arrive by correct scientific thinking and experimenting at the solution of a significant problem, rather than to recite a lesson, or do a stunt in the laboratory for the rather uninteresting purpose of getting a passable mark or escaping such disagreeable consequences as may be expected to follow a failure to satisfy the teacher's demands.

"This difference in the attitude of the pupil toward the unit of instruction may seem to some to be of little consequence so long as the pupils do the required work; but it is really the condition that determines whether the work of the instructor shall be real scientific teaching or mere perfunctory school keeping. It is the condition that determines whether the pupils are to get training that shall make them at home among scientific ideas and scientific or practical problems, or are merely to be crammed with words and processes that they cannot intelligently connect with things that are meaningful to them in life. * * * To effect his adjustment to his environment man must understand it—he must comprehend it; and herein lies the central motive for the study of geography. The process of adjustment, which is life itself, gives rise to multitudes of problems to be solved. Problems of vital utility and problems of absorbing intellectual interest grow directly out of the pupil's daily life, and reach out to the distant parts of the earth and through millions of miles of space to the sun." [11]

The problem method of teaching, founded on proved psychological principles, and advocated by our keenest philosophical thinkers in

[11] G. R. Twiss: The Natural Sciences, in Monroe's *Principles of Secondary Education*, Chap. XII. New York, Macmillan Company, 1915.

education, is making every educational worker in each great field of study stop, look, think,—and then think again.

The Junior High School is requiring an organization of high school geography work to meet a new need. General Science is crowding geography, or more properly physical geography, from its time-honored place in the first years of high school work, and makes necessary a reconsideration of where geography shall be placed and what shall be taught. The recent development of the problem method of teaching—an old friend that the best teachers have long used unconsciously—is now becoming a rough tool for the beginner and the novice.

As a result, geography, which we believe has worth that cannot be challenged, must be approached from a new standpoint. If the geographers do not help in this reorganization and redirection of geography, the task will be taken from our hands and chaos may result. A study of the literature of geography teaching shows that many educational leaders do not realize the significance or the beauties of the subject. They accept the table of contents of the formal texts on physical and commercial geography (of which nearly thirty different ones are now in use) as a digest of geography, not of special phases thereof, and either discard the subject as beyond redemption, or accept it as something that must be endured. Few realize that there is any other geography than the physical and commercial geography of the last few years, though several reports advocating the development of regional geography, and the humanizing of physical geography have been widely distributed and much discussed in recent years.

A study of the printed courses of study of 219 high schools from all parts of the country, of the answers to a series of questions received from 76 superintendents in large cities, of 24 replies to a similar questionnaire sent to a much larger number of high school teachers,—selected mainly by members of this association as the best and most successful teachers they knew,—as well as 17 replies to a questionnaire sent recently to members of this association, shows emphatically that geography in high schools is in a rut and generally out of favor.

The printed announcements of 219 high schools, incomplete as they are as to details, indicate that geography is increasing in significance only in business or commercial courses. Excursions and field work are offered in but few schools; laboratory work is noted but rarely. The most favorable fact is that in more than half the schools giving geography, five hours a week are devoted to it, a fact more characteristic of business courses than of other courses. The dry facts as to the status of geography are sufficiently discouraging, but the detailed reasons for the facts, as given by teachers and superintendents, are even more so. We can draw many conclusions according to our interests and points of view, as to why geography teaching is not more successful in secondary schools. We would all probably agree that

geography in secondary schools suffers because it is not tied up with the earlier work and leads nowhere. Geography in schools lacks unity of purpose and hence strength. We, as geographers, have been putting our approval on a type of secondary school geography in no way related to or based on the earlier school work. Students in the stress of secondary schools can have no working use of the details of their earlier years, unless those details are used in their regular work. When pupils have been exposed to no locational work for five or six years, certainly since they left the seventh grade of the elementary school, have college and normal school teachers a right to charge ignorance of location as the chief geographical weakness of high school graduates? Have we been consistent or far-sighted? When teachers are seemingly unaware, as their replies would indicate, that there is anything new in methods of geography teaching, or that they need pay attention to educational principles or movements, can we wonder that geography is not, to put it mildly, a universally sought elective.

We lament the poor teaching of geography in high schools and yet do not aid in its betterment either by showing how to get the real spirit of geography into the formal work, or by paying heed to the tendencies of educational thought. We cannot play ostriches any longer and be self-satisfied in our exposed isolation. Neither can we rightly criticize geography teaching in secondary schools as being bad when in most high schools, outside of a few large cities, the geography work is not sufficient to demand the full time of an adequately trained teacher. Today, as shown by the replies received from questionnaires, and in the report[12] of a study in the high schools of the Middle West, the *special* teacher of geography is rare. Of fifty-eight teachers of geography in fifty-three high schools, eight taught geography only, and these were all in one school. The specially trained teacher of geography is even rarer. Of the fifty-eight teachers mentioned, only nine had had more than one year's work in geography in normal school or college. Usually the teacher of geography teaches one or more other sciences, or some other subjects, perhaps physical training or stenography. The usual teacher of geography is a teacher of science or commercial subjects.

The lack of trained teachers of geography in the high schools is not due to lack of supply so much as to a lack of demand. An increased demand will bring a supply. We must put a new spirit and a new content into high school geography. The testimony secured from all available sources shows that for the country as a whole high school geography is today in a slough of despond as deep as was the case before the revolutionary report of the Committee of Ten in 1893. Other subjects have responded to educational demands, but geography has changed but little in content or spirit, as the statistics as to the

[12] E. E. Ramsey: Physical Geography in the High School, *School Science and Mathematics*, Vol. 11, 1911, pp. 838-848; Vol. 12, 1912, pp. 45-54, 114-125.

text-books most used by untrained teachers indicate. There is a new physics and a new history, but geography has not kept pace with the subjects to which it is most closely allied. The most modern text-books of history, once a dry listing of events as formal as the asteroids that still find a place in some courses of physical geography, are today appealing presentations of the evolution of human institutions and of human public opinion. The authors are presenting human activities of the past against the background of the geographic conditions. The details of the history of old are there, but the emphasis is on their significance at the time and on their influence on future events. The modern text in high school history is a text almost in applied human geography.

Meanwhile the old content of physical geography for secondary schools has persisted with but little change, or, if we have included any phases of applied geography in our texts we have often done so in a forced or perhaps even apologetic way. In recent years some teachers and writers have made significant advances in humanizing physical geography, but so great is the inertia of the past that no one has as yet put forth any complete constructive program for the future High School geography, which must be educationally sound, geographically strong and broad, and really worth studying for the usableness of its content. It is in part due to the demand that geography shall be worth while that we owe the present tremendous significance of commercial geography, as yet not wholly devoid of its lists of "furs, feathers, gums and resins."

Whether it be in physical or commercial geography, pupils in secondary schools are today largely memorizing facts and principles, often with no conception of their relative significance or relationships, even when accompanied by so-called laboratory work. In fact the character of the often forced laboratory work has been, and still is, a large factor in making secondary school geography formal and remote. When a school program calls for two or three class periods a week, and a double laboratory period, as is often the case, work must be ready for the laboratory period, whether it is useful, pertinent or just 'busy work.' Laboratory work for secondary school courses in physical and commercial geography is often a strange mixture of the pertinent and the impertinent. One problem may be too severe for a trained university graduate student to perform in the required time and the next may be so simple and obvious that it would be solved offhand by a bright child in the fourth grade of the elementary school. Exercises devoted to the identification of minerals and rocks, to the blind copying of maps from a text, or to the drawing of layers of a sand bank, so common in college entrance notebooks, indicate how abundant is 'busy work' with no relation to the course of study or the text-book. Certainly separate laboratory periods in the early years of the high school course are pedagogically unwise. In these

formative years training in how to study with the least waste, but not necessarily the least expenditure of energy, is a vital part of school work. The teacher should be free to teach every class period by such methods as will best promote the efficiency of his pupils and their advancement in understanding and appreciation of the subject involved. The study of geographical facts, either first hand or through some graphic representation of them, should be a constant feature in early geographic training and not a stunt set for a certain special time.

Geography for secondary schools will in time be geography—and geography is not a synonym for physical or commercial geography. Geography is a human as much as it is an earth science. Its larger problems are human problems that involve a study not only of the influencing conditions of the physical environment, but of the economic and social conditions that may be as basic as the physical conditions. These larger problems are not wholly commercial or industrial. Commercial geography bears about the same relation to human geography that the physiography of the land or water does to physical geography. It is only a special phase of the larger subject, but a phase that cannot be ignored in any complete study.

Some problems of human geography are so inclusive and involved that they can only be efficiently handled by a past master in the subject. Others are so simple and personal and appealing that they have long formed a part of the work in the early years of the elementary school. It is possible to select a series of problems in human geography, adapted to the needs, interests and abilities of adolescent pupils, and through the study of such problems to develop the principles of human and physical geography. Real problems appreciated by the pupils as worth solving at the time need not be merely of temporary interest or value. The simpler and more personal problems may serve as an introduction to larger, less personal but no less interesting national or international problems until one comes to the limits of powers of secondary pupils. Pupils who leave the secondary school with an interest in the larger problems still before them, and with a knowledge of how to approach these problems in later years, are, at least in part, prepared for their life task, which will consist of solving problems. An interest in and an ability to attack problems of the intellect are contributions to life preparation and life satisfactions devoutly to be sought as purposes in education. Geography is a vibrant and not a static science. Its scope and limits are not fixed; it is a life science dealing with living things and evolutionary forces.

Our secondary texts and courses of study have unconsciously been framed to give pupils the impression that the subject is fixed, definite and complete—and that there is nothing more to be learned beyond the cover of the given book. Our methods of teaching have confirmed pupils in the belief and the hope they will not be disappointed in the belief.

The problem method of approach enables us to deal with the same basal content, so as to make it a life-giving and thought-provoking subject. Further, this method will minimize the deadening influence of pure memory work which so long was considered as the main phase of teaching. Facts and principles will be remembered because they are useful and because they are properly associated psychologically. 'Discipline' will be secured through the efficient training of the enquiring mind in solving scientific problems, and the methods of work employed will make easier the study of other sciences approached in the same way.

This vitalized geography will be organized according to educational principles and will make use of the methods of teaching known to be best adapted to adolescence. Laboratory work, recitations, quizzes, or any other desirable plan will be brought in when most serviceable. The development of the individual and class will go hand in hand with the development of the subject and not lag so far behind that it may be forgotten as a purpose in teaching. The preceding General Science will lay a foundation of content and method for humanized geography, and the breaks between the sciences will be less obvious than at present. The classifications and categories, so beloved by the adult expert, will be introduced as they are needed and can be used in an understanding way. The classes of land forms that are intelligible only to the adult trained in structural geology will be dropped from our secondary texts and courses of study. The principles of climatology will receive greater emphasis and the significant generalizations of human geography will be made prominent.

The new geography will lead pupils to appreciate the physical, economic and social causes underlying the consequences seen in human and life geography, so far as their age and powers will permit. This new geography will find its application in history, in economics and the other distributive subjects. Location will come back because the course will deal with facts and relations placed somewhere, and centering around some human group and its problems. Being a subject of value in the interpretation of human affairs, in making clear the story of the past as well as the conditions of the present, it will be used in other subjects. The historians have already shown a way in which geography can be made serviceable to them. Perhaps the geography teacher of the future in many secondary schools will be the teacher of history or economics—certainly he would probably be more effective than a teacher of typewriting or commercial law.

This in brief is the general plan of the geography in high schools in the near future, as many educators and geographers see it. Some teachers have been teaching this type of geography for several years in spite of the difficulties confronting them. They are the forceful few, who have caught the spirit of modern geography and, trained in its content and in education, have dared to experiment.

Any effective reorganization of high school geography to meet "the situation that confronts us," the beginning of a revolution in geography teaching as epochal as that of the Nineties,—depends on many practical factors. We must have text-books in human and physical geography organized scientifically and better unified than many of the current books on commercial geography. As the new geography will involve the study not only of the distribution of people but of the forms of life on which humanity depends, and will incude a study of countries as well as people, we must have an adequate school atlas for America, similar to but yet different from those available in several countries abroad. We must have class-room guides involving the study of other geographic materials than text-books and atlases and yet not wholly dependent upon topographic maps, agricultural bulletins and census reports, which are often mere makeshifts for the real thing. Finally we must have teachers of proper training, who have caught the spirit of geography and of modern education, and who want to teach youths geography and not merely some phase of geography to youths. The demand for teachers of this type, which already in fact exists, may involve our colleges and normal schools, few of which as yet pay much attention to geography.[13] Perhaps, the day will come when the paths blazed by a few colleges, and relatively fewer normals, in real geography teaching will be more generally followed and geography will come to its own in American education. The opportunity and demand are here, the responsibility confronts us. Self-preservation, and the increasing number of geographers who are winning their way to the front through their studies of life geography, would seem to suggest the lines of advance we should follow.

Geography cannot be what it should if educational leaders, untrained in geography, are to direct its future course. Neither can a geographer develop his subject to its highest degree if he looks at it only from the window that has given him the most pleasing vistas of the science and pays no heed to the subject as a whole, or to the new conditions that modern educational science has brought about. Knowledge is becoming more and more specialized; progress is being made so fast in all sciences that the all-round naturalist, able to teach any science well, is almost an impossibility. Modern education is a science and an art. It is the necessary handmaid of all subjects that should enter into the training of youth. Let us then seek its aid. With our eyes turned ever toward the ideal, and yet recognizing that it is a practical problem before us, let us take such steps into the future as the best testimony of all interested, specially trained experts in the several cooperating sciences, warrants. Then geography, being proved of value and not merely taken on authority, will come into its own in all phases of education.

[13] A Study of Geography in Normal Schools, *Teachers College Record*, March, 1914, pp. 1-12.

ANNALS OF THE ASSOCIATION OF AMERICAN GEOGRAPHERS
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PHYSIOGRAPHIC DIVISIONS OF THE UNITED STATES

NEVIN M. FENNEMAN

CONTENTS

Introduction.

Demand for Natural Divisions.—A number of attempts have been made to divide the United States into natural or physical units which should be as nearly as possible homogeneous with respect to certain criteria. Recent demands for such a division of the United States have come from various sources. Within four weeks such requests came to the United States Geological Survey (or its members) from the Forestry Bureau, the Division of Pomology (United States Department of Agriculture), a state geologist engaged in economic work, and from several geographers. In educational work there is constant need of a scheme of natural divisions which may be described or explained as units.

Official surveys, State and National, are annually describing a large number of small areas. In most cases some attention is given to the geographic setting of such areas and to physiographic description or explanation. Such chapters or paragraphs are commonly headed Geography, or Physiography or Topography. In describing a quad-

rangle, county, or other area, it is common to refer it to some larger area, generally called a province, though that word has been used very loosely. The implication of this, beside merely locating the field, is that the province is recognized as having certain characteristics and that in locating the field within it, a general impression of the character of the smaller area is imparted. The province, with its known characteristics, is mentioned chiefly to give a setting for the smaller field. When used in this way, the value of the province depends largely on its homogeneity.

Work of the Association of American Geographers.—For several years past the Association of American Geographers has interested itself in the work here proposed. Two lengthy papers were presented at the Princeton meeting in December, 1913, and published in the Annals of the Association, Vol. IV, 1914.[1] At the Chicago meeting of the Association in December, 1914, a round-table conference was devoted to the subject.

Following these events a committee was appointed to devise a systematic division of the United States. This committee consists of Messrs. M. R. Campbell and F. E. Matthes of the United States Geological Survey, Professors D. W. Johnson of Columbia University, Eliot Blackwelder of the University of Illinois (formerly of Wisconsin), and Nevin M. Fenneman of the University of Cincinnati (chairman). The detailed work of this committee was performed largely by a subcommittee consisting of Messrs. Matthes, Campbell and Fenneman. From December 20, 1915, to April 20, 1916, this subcommittee sat from three to four half-days per week. Between these sessions information was sought and counsel taken from a large number of geologists selected because of special familiarity with various parts of the United States.

The results of the above committee's work are incorporated in a map of the United States (Plate I) showing divisions of three orders, called respectively, major divisions, provinces, and sections. This map, together with the naming and classification of the several units, constitutes the committee's report. This report is unanimous except on several points to which exception is taken in footnotes to this paper. Such footnotes will be found on pages 32 and 59. This paper (except as to the items named above) is not a part of the com-

[1] W. L. G. Joerg: The Subdivision of North America into Physiographic Regions, *Annals of Assoc. of Amer. Geogr.*, Vol. IV, 1914, pp. 55-84. This paper dealt more particularly with divisions of a more generalized character, based not on physiography alone, but even more on vegetation as the result and index of physiography and climate.

Nevin M. Fenneman: Physiographic Boundaries within the United States, *ibid.*, pp. 84-134. This paper was accompanied by a proposed preliminary map. Most of the boundary lines given on that map are retained on the map here presented, Plate I, though some are changed in rank and many new lines are added.

mittee's report. It is believed by the writer, however, to agree generally with the committee's judgments. No member of the committee would claim finality for this work, especially as to the exact locations of boundary lines. Minor changes in this respect are to be expected with increasing knowledge. Some new divisions may be recognized and subdivisions of lower orders are to be expected. There is, on the other hand, little reason to doubt that nearly all of the divisions here given will continue to be recognized and distinguished from their neighbors on the basis here given.

The committee's responsibility ends with the United States, but most of the major divisions and many of the minor ones extend into Canada or Mexico. It was necessary, therefore, to give considerable study to those countries when dealing with units which overlap international boundaries. As the result of such a study it is confidently expected that when the time comes to delineate the physiographic divisions of the continent of North America, those now set forth for the United States can be incorporated without change.

General Principles.—Necessarily the first consideration of the committee pertained to the basis or criterion of division. It is not enough to say that a division shall be *natural* or even *physiographic.* Various elements enter into the "nature" and "physiography" of an area. It is plain that the division of a continent or country into its natural units will depend on what elements of nature are considered as dominant. An area may be homogeneous, that is, it may be a unit with respect to one element or principle, and heterogeneous with respect to another. The point of view from which this paper is written may best be made clear by a few general principles:

(1) Physiography is the science which treats of the earth's *surface.* It is therefore an essential part of the more comprehensive science of geology which treats of the earth's *crust* in all its aspects. Both sciences have their descriptive, dynamic and historic phases. Structure, in so far as it affects topography, belongs equally to both sciences.

(2) Surface forms are determined by (a) structure, (b) process, and (c) stage. In this formula by Professor Davis the word *structure* indicates the product of all *constructional* agencies. It includes the nature of the material, its mode of aggregation and even the form before the work of erosive agencies begins. In other words, it stands for that upon which erosive agents are, and have been, at work.

The second factor, *process,* refers to the erosive agency by which the original structure is being destroyed. It may be normal erosion,[2]

[2] The term "normal erosion" is plainly open to criticism on the ground that one mode is just as normal as another, but no other satisfactory term has been proposed. The term "stream erosion" excludes the very important work of unconcentrated wash: "water erosion" would include the work of waves on shores, which must be treated as a distinct type.

glacial, wind or wave erosion. Each of these processes produces its own characteristic forms, differing according to the structure upon which it acts. The third factor, *stage*, indicates that in the destruction of a land form by any one of the above-named processes, the form passes through a regular cycle of changes as the work progresses. Each stage has its own characteristics, differing according to the process at work and the structure involved. A type of topography may therefore be designated by stating the initial structure, the erosive process at work and the stage reached in the cycle.

In general, any difference in structure, process or stage will reveal itself in a difference of resultant forms. (The only important exception to this is that perfect peneplains would be much alike, whatever the structure.) The converse of this principle is likewise true, namely, that any difference between two land forms results from some difference in structure, process or stage. Briefly stated, these constitute the history of a topographic form. While structure itself is not an event, it nevertheless conditions all events so that it is impossible for the same erosive processes to advance in the same manner where structures differ. It may, therefore, be stated in general terms that two areas having different topographies have had different physiographic histories.

The physiographic history of the United States may be thought of as a great number of events, constructional and destructional, each affecting a certain area, large or small; of uniform or diverse structure; in general, no two events affecting exactly the same area, but overlapping, some much, some little. Within the area affected by one event, the topography will differ in different parts; it may be because of differing structure or because of the complicating effects of other events.

Following this reasoning, it would seem at first that the surface of the United States would be subdivided into an almost infinite number of small units distinguished by diverse histories and topographies. The number of crustal movements, erosion cycles and interrupting events has indeed been very large, but the final result is greatly simplified by the obliteration of older effects by later events. The making of the last peneplain destroys all former topographies; and the topographic effect of glaciation may dominate all other forms. Structure is the one thing that persists and, though dating from early geologic time, may continue to dominate the topography. When this is remembered, it is not surprising to find that strong topographic contrasts between large areas are more often caused by structural contrasts than by different agents of erosion or different stage in the cycle. Thus, many well-marked topographic divisions can best be defined by stating that they are coextensive with certain elements of structure.

Physiographic Maps.—In depicting the physiography of a continent

(including of course its genesis) at least two kinds of maps are desirable. The first would distinguish the areas affected by the great events of physiographic history (e. g., the Appalachian uplift, the Kittatinny peneplain, the several glacial invasions, the late Tertiary lava flows, the alluviation of the Great Plains). The second kind of map would distinguish the present aspects of the surface, altitude and style of topography being the chief elements considered. The first kind of map (or rather a series of such, made necessary by the complex overlapping of the areas) would depict the main points in the physiographic history of any locality. The second type of map represents the *end product* of all events and conditions. On such a map it may generally be said that the surface of each areal division is characterized by a certain structure and a few dominant events, so few that the effects of each are still apparent. If, on a map of the first kind, the area affected by each event be narrowed to that in which the effects of that event help to dominate the topography, overlapping will, to a large extent, disappear and the divisions shown on the first map will approach those of the second map.

It is evident that of these two kinds of physiographic maps, the second is relatively easy to draw, since it involves chiefly a knowledge of present-day forms. But it is not to be inferred that the kind of knowledge referred to is merely empirical, such as would class the High Plateaus of Utah with the Wasatch Mountains because they are equally high and their slopes perhaps equally rugged, or the Triassic lowland of New Jersey with the Coastal Plain. Although the physiographer in preparing such a map takes account of forms, he nevertheless considers these forms as the products of certain events which have taken place on certain structures. The unity or homogeneity of a province is not in mere external similarity of forms, but is such as to make it possible to explain the topography of the entire area in a consistent account of its history. If the end products of two diverse histories are superficially similar, it is none the less necessary to distinguish them on the map in order that their physiographic relations may be pointed out. In like manner it may happen that the map includes, in one province, forms which are superficially diverse, because of their physiographic relationship. Such is the case with the hilly inner edge and the flat outer edge of the Coastal Plain. Hence, in making *form* the primary basis of subdivision, it is understood to be *form as the result* of certain processes. Otherwise the descriptions must be merely empirical.

For a large part of the United States, maps of the first kind have not yet been drawn and are impossible in the present state of knowledge. Their construction waits on accurate topographic surveys and detailed physiographic studies.

All the above considerations are concerned with the history of a

province, or what is nearly the same thing, with the explanatory description of its topography. For both these purposes their usefulness is in proportion to their unity. The great end desired is that in each case the maximum number of general statements may be made with the minimum necessity for considering details and exceptions. It is, however, a matter of coördinate importance that these divisions shall also be useful in the consideration of the effect of topography on human affairs. Thus the consideration of physiographic divisions looks both ways—backward to geology and forward to geography. With reference to the former, topography is an effect; with reference to the latter it is a cause. In geology, topography is an end product; in geography, with its various biologic and economic phases, it is a point of departure. The demand for physiographic provinces has naturally been strongest among geographers and others whose work is based on such distinctions; but to determine what these units are and to define and delimit them must be largely the work of geologists.

Nature of Boundary Lines.—In speaking of the criteria by which provinces are distinguished, a distinction must be made between the essential characteristics of the province and the basis on which the exact boundary is determined. Ideally, it would seem that the line should be drawn where the characteristics of one province leave off and those of the next begin. If every case were simple, if there were no gradations, no odds and ends of doubtful or neutral character, if no generalizing were necessary, if a province were characterized by just one essential, or if the several leading characteristics of an area were coextensive, it would be easy to draw the line as stated above. In practice it happens that a province may be so strongly characterized as to compel the recognition of its individuality, though its boundary may be very indefinite, or the characteristics may come to an end one by one. This is illustrated in the boundary between the Great Basin and the Columbia Plateau, two of the most strongly-individualized provinces of the United States. In delimiting one from the other (see p. 84), it is impossible to draw the entire boundary by any one criterion. The practice followed in making the divisions here presented has been to determine, first, whether a given region deserves recognition and then to choose the boldest or the most consistent line available. It may thus happen that the major divisions are locally separated by very poorly defined lines while nearby lines separating minor divisions may be very bold.

The boundaries of most of the units in the system here presented correspond more or less exactly to geologic lines which indicate the reasons for the contrast in elevation or style of topography. Frequently such geologic lines may be regarded as *interpretative*. For example, the eastern boundary of the Cumberland Plateau not only

agrees with the edge of the Carboniferous strata, but is to be explained by it. A similar relation exists between the western boundary of the Texas coastal plain and the Balcones fault. In like manner most of the sections of the Central Lowlands are separated by lines which mark the limits of drift sheets. Most of the lines are subject to some such interpretation related to the underlying rocks, that is, to *structure* in the broad sense used by Davis.

In a few cases the contrast of topography or elevation between adjacent divisions is not accompanied by, or dependent on any structural feature or difference in materials. Such topographic contrast may indicate different stages in the erosion cycle. This is illustrated by the east foot of the Blue Ridge and a few other escarpments which follow no interpretative lines. Some lines are arbitrary. Some of these follow natural lines, arbitrarily chosen, as the Missouri River is chosen to delimit the Ozark Plateaus on the north, or the Wabash River to separate the Till Plains from the Eastern Lake Section of the Central Lowland. Others, like the line cutting off the Floridian Section of the Coastal Plain, are merely straight lines, which, within limits of a number of miles, might as well be drawn at one place as another. The Floridian Section is a good example of a strongly characterized division, deserving recognition, but not capable of separation from its neighbor by any well-marked line.

All lines are necessarily generalized, owing to the scale of the base map. The determination as to whether a certain point near a boundary lies in one division or the other must rest ultimately on the definition and description of the several units and not on the accuracy of the map maker. Where the boundary between a high plateau and a low one is exceedingly irregular, like the western escarpment of the Cumberland Plateau, the flat promontories are portions of the higher province and the flat valleys intervening are portions of the lower province. They should be so represented on maps of sufficiently large scale.

The nature of topographic boundaries is such that exactness is possible only *within limits*. The limits may be a few feet or a few miles. Where the natural boundary is vague it is not well to use categorical language in speaking of localities which are close to the generalized conventional boundary line. Probably much more than nine-tenths of the area of the United States can be spoken of unequivocally as lying in one province or another, but the remaining fraction must be spoken of in terms which suggest gradation or in some cases even uncertainty. A few concrete cases will illustrate the spirit of this:

On the map (Pl. I) the Laurentian Highland in northeastern Minnesota is separated from the Western Lake Section of the Central Lowland by a broken line which ignores all detail. This is because the characteristics of the Laurentian Highland disappear not only gradu-

ally but interruptedly. The two provinces are, so to speak, interlocked (p. 65). To follow the map rigorously and speak of places near the line as belonging categorically to one province or the other without suggesting the gradation, would leave a false impression. Such a locality may well be described as lying in the zone of gradation but related by its character to one or the other province. This does not invalidate the Laurentian Plain as a major division of the continent, but it acknowledges the local weakness of the boundary.

Hamilton County, Ohio (containing Cincinnati), lies wholly within the technical limits of the Till Plains (see p. 66). But in order to leave a correct impression it is necessary to state that the area considered is on the southern border of the Till Plains where their character gives way gradually to that of the Interior Low Plateau.

A number of counties in eastern Nebraska may well be spoken of as "in the zone where the Central Lowland merges into the Great Plains," tho they may be said to be on this or that side of "the line conventionally taken as the boundary" (see p. 61).

To speak of the Joplin District in southwestern Missouri as within the Ozark Plateau would be technically correct if the customary conventional limit is used (see p. 66), but to use language implying categorical distinctions and sharp outlines would leave an exaggerated impression of the difference between this county and the adjoining county in the Osage Plains of Kansas.

A further result of generalization is the occurrence of outliers or inliers. The Black Hills, Little Rockies and Highwood Mountains are of the same types as some of the Rocky Mountains, but if a Great Plains province is justified at all it must completely surround and include these isolated mountains. They themselves are not "plains," but they are in the Great Plains *province,* being exceptional features of it, and not a part of the Rocky Mountain province in the sense here used.

Major and Minor Divisions.—The continent of North America is first divided into eight strongly characterized parts, all of these being represented in the United States and all but two of them in Canada. These are here called *major divisions.* The term "division" cannot, however, be restricted to this one sense. Units of the next smaller order are here called *provinces,* many of them having borne that designation for a long time. Units of the third order are here called *sections.* The word *district* is here used for divisions of low, generally undetermined order whose boundaries are as yet undefined.

The basis on which the major divisions are distinguished is not essentially different from that which is assumed in distinguishing the smaller units. It is easier, however, to correlate the major divisions with the great constructional events of geologic history. Differences

based on erosional histories may be relatively more important in distinguishing the units of lower order, but the bases recognized in the two cases differ only in degree. The distinction is not absolute.

All orders of divisions rest ultimately on existing differences in topography and elevation. But the differences considered are those which pertain to physiographic types and not merely superficial appearance. It would be difficult to formulate a rule to determine which units should be made major and which minor. Size can not be wholly ignored. The degree of unity or complexity is probably more important. Closely related to this is the strength of the characteristics or individuality of an area. Concerning the satisfactoriness of correlations made by such indefinite criteria it can only be said that, while the recognition and the delimitation of most of the units involved much discussion and conference in the committee above mentioned (p. 21), there was little difference of opinion concerning the rank to be assigned to each unit.

The Naming of Divisions.—So far as possible each division of whatever order has been given a proper name and a topographic designation. In a few cases the proper name is replaced by such terms as "central" or "interior," or by other distinctive terms as in case of the Dissected Till Plains. In some cases the proper names are applied in their customary sense, e. g., the Rocky Mountain and Appalachian divisions, or the Piedmont and Ozark plateaus. In other cases it has been necessary to take a proper name from an important city or other feature in the larger area, e. g., the Walla Walla plateau and the Salton trough.

In all cases where the name is descriptive, it is assumed to designate the most prominent characteristic of the area and not the character of the whole. Thus the Great Plains Province is by no means all *great plains,* nor are the Appalachian Highlands all *highlands*.

Where topographic character is so varied or complex that any single descriptive term would be misleading, the proper name is followed by the mere word *province,* e. g., the New England province.

Classified List of Divisions

The tabular summary (pp. 30-35) shows the divisions of the several orders in classified form. The provinces are numbered consecutively and the sections of each are lettered. These numbers and letters correspond to those on the map, Plate I, on which each section bears the number of its province and its own letter. In the column headed "characteristics," exactness of detail is necessarily sacrificed to brevity. Characteristics are stated wherever possible in terms of a genetic classification of land forms in order to convey to physiographers the best mental pictures in the fewest words.

For Tabular Summary

See pp. 30-35

PHYSIOGRAPHIC DIVISIONS

MAJOR DIVISION	PROVINCE	SECTION
Laurentian Upland	1. Superior Upland	
Atlantic Plain	2. Continental Shelf	
	3. Coastal Plain	a. Embayed section
		b. Sea Island section
		c. Floridian section
		d. East Gulf Coastal Plain
		e. Mississippi Alluvial Plain
		f. West Gulf Coastal Plain
Appalachian Highlands	4. Piedmont Province	a. Piedmont Upland
		b. Triassic Lowland
	5. Blue Ridge Province	a. Northern section
		b. Southern section
	6. Appalachian Valley Province	a. Tennessee section
		b. Middle section
		c. Hudson Valley
	7. St. Lawrence Valley	a. Champlain section
		b. Northern section
	8. Appalachian Plateaus	a. Mohawk section
		b. Catskill section
		c. Allegheny plateau, glaciated section
		d. Allegheny plateau, Conemaugh section*
		e. Allegheny plateau, Kanawha section
		f. Cumberland section
	9. New England Province	a. New England Upland
		b. White Mountain section
		c. Green Mountain section
		d. Taconic section
	10. Adirondack Province	

* In the report of the Committee this is called the unglaciated section of the Allegheny Plateau, and the Kanawha Section is not made a part of the Allegheny Plateau.

OF THE UNITED STATES

CHARACTERISTICS[a]

1. Submaturely dissected, recently glaciated peneplain on crystalline rocks of complex structure.
2. Sloping submarine plain of aggradation.

3a. Submaturely dissected and partially submerged, terraced coastal plain.

3b. Young to mature terraced coastal plain with submerged border.

3c. Young marine plain: sandhills, swamps, sinks and lakes.

3d. Young to mature belted coastal plain.

3e. Flood plain and delta.

3f. Young, grading inland to mature, coastal plain.

4a. Submaturely dissected peneplain on disordered resistant rocks; moderate relief.[b]

4b. Slightly uplifted peneplain on inclined weak strata; residual ridges on volcanic sheets.

5a. Maturely dissected mountains of crystalline rocks; accordant altitudes.

5b. Mature to subdued mountains of disordered crystalline rocks.

6a. Second-cycle mountains of folded strong and weak strata; valley belts predominating over even-crested ridges.

6b. The same, but with even-crested ridges predominating over valley belts except on southeast side.

6c. Glaciated peneplain on weak folded strata.

7a. Rolling lowland, glaciated; in part covered by young marine plain.

7b. Young marine plain with local rock hills.

8a. Maturely dissected, glaciated plateau; varied relief.

8b. Maturely dissected, plateau of mountainous relief and coarse texture (glaciated).

8c. Submature, glaciated plateau of moderate to strong relief.

8d. Submature plateau of moderate to strong relief.

8e. Mature plateau of fine texture; generally strong relief.

8f. Submaturely dissected plateau of moderate to strong relief.

9a. Dissected and glaciated peneplain on disordered rocks; monadnocks.

9b. Monadnock group of late mature glaciated mountains of crystalline rocks.

9c. Linear ranges of subdued and glaciated mountains and residual plateaus.

9d. Maturely dissected and glaciated mountains and peneplain of resistant complexly folded strata.

10. Subdued mountains and dissected peneplain, glaciated.

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[a]—Prepared by Nevin M. Fenneman and Douglas W. Johnson.

[b]—Degrees of relief are herein spoken of as low, moderate, strong and high. As used here *high* relief is measured in thousands of feet; *moderate* relief in hundreds of feet. *Strong* relief may be anything approaching 1,000 feet with a wide latitude on both sides.

PHYSIOGRAPHIC DIVISIONS OF

MAJOR DIVISION	PROVINCE	SECTION
Interior Plains	11. Interior Low Plateaus†	a. Highland Rim Plateau
		b. Lexington Plain
		c. Nashville Basin
		d. Western (unnamed) section
	12. Central Lowland	a. Eastern lake section
		b. Western lake section
		c. Wisconsin Driftless section
		d. Till Plains
		e. Dissected Till Plains
		f. Osage Plains
	13. Great Plains Province	a. Missouri Plateau, glaciated‡
		b. Missouri Plateau, unglaciated
		c. Black Hills
		d. High Plains
		e. Plains Border
		f. Colorado Piedmont
		g. Raton section
		h. Pecos Valley
		i. Edwards Plateau
		k. Texas Hill section
Interior Highlands§	14. Ozark Plateaus	a. Springfield-Salem plateaus
		b. Boston "Mountains"
	15. Ouachita Province	a. Arkansas Valley
		b. Ouachita Mountains
Rocky Mountain System	16. Southern Rocky Mountains	
	17. Wyoming Basin	
	18. Northern Rocky Mountains	

† In the report of the Committee, this is called the Highland Rim Province. Messrs. Campbell and Matthes do not agree to the exclusion of the entire province from the Appalachian Highlands. They believe this province should be divided into two, and that the eastern portion, including the Lexington Plain and Nashville Basin should be included in the Appalachian Highland. (See footnote, p. 59, for comment on classification and name.)

‡ In the report of the committee this is called the "Glaciated section of the Great Plains."

§ In the report of the committee this division is called Ozarkian Highlands.

THE UNITED STATES—Continued

CHARACTERISTICS

11a. Young to mature plateau of moderate relief.

11b. Late mature to old plain on weak rocks; trenched by main rivers.

11c. Late mature to old plain on weak rocks; slightly uplifted and moderately dissected.

11d. Low, maturely dissected plateau with silt-filled valleys.

12a. Maturely dissected and glaciated cuestas and lowlands; moraines, lakes, and lacustrine plains.

12b. Young glaciated plain; moraines, lakes, and lacustrine plains.

12c. Maturely dissected plateau and lowland invaded by outwash plain. (Margin of old eroded drift included.)

12d. Young till plains; morainic topography rare; no lakes.

12e. Submaturely to maturely eroded till plains.

12f. Old scarped plains beveling faintly inclined strata.

13a. Glaciated old plateaus; isolated mountains.

13b. Old plateau; local badlands; isolated mountains.

13c. Maturely dissected domed mountains.

13d. Broad inter-valley remnants of smooth fluviatile plains.

13e. Maturely dissected plateau.

13f. Late mature to old elevated plain.

13g. Trenched peneplain surmounted by dissected, lava-capped plateaus and buttes.

13h. Late mature to old plain.

13i. Young to submature plateau of moderate to strong relief.

13k. Plateau in maturity and later stages of erosion.

14a. Submature to mature plateaus.

14b. Submature to mature plateau of strong relief.

15a. Gently folded strong and weak strata; peneplain with monadnock ridges.

15b. Second-cycle mountains of folded strong and weak strata.

16. Complex mountains of various types; intermont basins.

17. Elevated plains in various stages of erosion; isolated low mountains.

18. Complex mountains of various types; intermont basins.

PHYSIOGRAPHIC DIVISIONS OF

MAJOR DIVISION	PROVINCE	SECTION
Intermontane Plateaus	19. Columbia Plateaus....	a. Walla Walla Plateau..........
		b. Blue Mountain section........
		c. Payette section...............
		d. Snake River Plain............
		e. Harney section...............
	20. Colorado Plateaus.....	a. High Plateaus of Utah........
		b. Uinta Basin..................
		c. Canyon Lands................
		d. Navajo section...............
		e. Grand Canyon section.........
		f. Datil section.................
	21. Basin-and-Range Province............	a. Oregon Lake section..........
		b. Nevada Basin................
		c. Sonoran Desert..............
		d. Salton Trough................
		e. Mexican Highland............
		f. Sacramento section...........
Pacific Mountain System............	22. Sierra-Cascade Mountains.........	a. Northern Cascade Mountains..
		b. Middle Cascade Mountains....
		c. Southern Cascade Mountains..
		d. Sierra Nevada................
	23. Pacific Border Province	a. Puget Trough................
		b. Olympic Mountains...........
		c. Oregon Coast Range..........
		d. Klamath Mountains...........
		e. California Trough............
		f. California Coast Ranges.......
		g. Los Angeles Ranges...........
	24. Lower Californian Province...........	....

THE UNITED STATES—Concluded

CHARACTERISTICS

19a. Rolling plateau in youth of present cycle.

19b. Complex mountains and dissected volcanic plateaus.

19c. Young plateaus of prevailingly weak rocks; broad alluvial terraces. (Applies to northern part only.)

19d. Young lava plateau.

19e. Young lava plateau; canyons in northwest part.

20a. High block plateaus; in part lava-capped; includes terraced plateaus on south side.

20b. Dissected plateau; strong relief.

20c. Young to mature canyoned plateaus; high relief.

20d. Young plateaus; scarps and rock benches; grades into 20c.

20e. High block plateaus, trenched by Grand Canyon.

20f. Lava flows entire or in remnants; volcanic necks.

21a. Young block mountains and lake basins.

21b. Isolated ranges (probably dissected block mountains) separated by aggraded desert plains.

21c. Widely separated short ranges in desert plains.

21d. Desert alluvial slopes and delta plain; Gulf of California.

21e. Isolated ranges (probably dissected block mountains) separated by aggraded desert plains.

21f. Mature block mountains of gentle dip; block plateaus; bolsons.

22a. Sharp alpine summits of accordant height; higher volcanic cones.

22b. Generally accordant summits; higher volcanic cones.

22c. Volcanic mountains variously eroded; no very distinct range.

22d. Block mountain range tilted west; accordant crests; Alpine peaks near east side.

23a. Lowlands of diverse character; in part submerged.

23b. Generally accordant crests; local alpine peaks.

23c. Uplifted peneplain on weak rocks, dissected; monadnocks of igneous rock.

23d. Uplifted and dissected peneplain on strong rocks; extensive monadnock ranges.

23e. Low fluviatile plains.

23f. Parallel ranges and valleys; rounded crests of subequal height.

23g. Narrow ranges and broad fault blocks in various states of dissection.

24. Dissected west-sloping granite upland (in northern part).

DEFINITIONS.

The following definitions of major divisions, provinces, and sections are intended to give, where possible, the essential reason for the recognition of the area as a unit, and at the same time, by implication, to indicate its extent. In some cases this definition consists of a statement of character, similar to that given in the table, pp. 30 to 35, but with special reference to those features which distinguish the area from its neighbors. In other words, the statements here made *may be descriptive* but they *must be definite.* In some cases, especially those of mountains or intermontane valleys, the distinguishing character of an area is sufficient implied in its name. In such cases, the location is the only additional element which can be given. Many of the names are already in use, but with no exact limitations to their application. The essential thing in such cases is to make clear the sense in which the term is used. To specify the location of each unit in its definition would generally be a useless form of words since this is shown on the map, without which the definition would have little value.

THE LAURENTIAN UPLAND is that major division of North America lying chiefly in Canada, whose topography is characterized by a peneplain developed on strong rocks of complex structure and by the effects of later erosion and recent glaciation which has produced many rock-basined lakes.

1. **The Superior Upland** is the margin of the Laurentian Upland in the vicinity of Lake Superior.

THE ATLANTIC PLAIN is a major division of North America consisting of the Atlantic (including Gulf) Coastal Plain and the continental shelf.

2. **The Continental Shelf** is the submerged margin of the continental surface.

3. **The Coastal Plain** is a portion of the former continental shelf raised above the sea without essential deformation.

3a. *The Embayed Section* of the Coastal Plain is that part which is deeply indented by estuaries or cut off by sounds from the mainland.

3b. *The Sea Island Section* of the Coastal Plain is that part which drains to the Atlantic Ocean between the Embayed and Floridian sections.

3c. *The Floridian Section* of the Coastal Plain is that portion which is due to a local rather than to a continental uplift and emergence.

3d. *The East Gulf Coastal Plain* is that part which drains to the Gulf of Mexico between the Mississippi Alluvial Plain and the Floridian section.

3e. *The Mississippi Alluvial Plain* consists of the delta of the Mississippi and that portion of its floodplain which lies within the limits of the Coastal Plain.

3f. *The West Gulf Coastal Plain* (in the United States) is that portion which lies west of the Mississippi Alluvial Plain.

THE APPALACHIAN HIGHLANDS constitute a major division characterized in general by its relative altitude but including certain related lowlands.

4. **The Piedmont Province** consists of the plateaus and plains lying between the Coastal Plain and the first mountain range inland. (Conventionally, south of New York only.)

4a. *The Piedmont Upland* is the uplifted and partially-dissected plain of the Piedmont Province, developed on strong rocks having a complicated structure.

4b. *The Triassic Lowland* is a peneplain developed on soft (mainly Triassic) rocks within the Piedmont Province.

5. **The Blue Ridge Province** is the belt of contiguous mountains in the Appalachian Division, whose topography is controlled by strong rocks having a complicated structure.

5a. *The Northern Section* of the Blue Ridge Province is the narrow portion whose summit levels in general indicate a former peneplain.

5b. *The Southern Section* of the Blue Ridge Province is the broad portion whose summits in general rise above any discernible peneplain.

6. **The Appalachian Valley Province** is the longitudinal belt of valleys and included mountains which traverses the Appalachian Highlands.

6a. *The Tennessee Section* of the Appalachian Valley Province is its southern part, characterized by nearly straight, parallel mountain ridges and valleys produced by erosion on regular folds of alternating strong and weak strata, and by longitudinal drainage.

6b. *The Middle Section* of the Appalachian Valley Province is that part which is characterized by zigzag mountain ridges and canoe-shaped valleys produced by erosion on pitching folds of alternating strong and weak strata, and by transverse drainage.

6c. *The Hudson Valley* is a section of the Appalachian Valley Province drained by Hudson River and consisting of a broad valley without mountain ridges.

7. **The St. Lawrence Valley** is the lowland north of and con-

tinuous with the Hudson Valley, enclosed between the New England Province, the Adirondack Province and the Laurentian Highland.

7a. *The Champlain Valley* is a section of the St. Lawrence Valley between the New England and Adirondack provinces and characterized by greater relief than the average for the province.

7b. *The Northern Section*[3] (or sections) of the St. Lawrence Valley embraces all north of the Adirondack Province and Champlain Valley and consists mainly of a young marine plain.

8. **The Appalachian Plateaus** comprise that portion of the Appalachian Highlands which consists essentially of elevated and more or less dissected horizontal strata.

8a. *The Mohawk Section* of the Appalachian Plateaus is that part which lies north of the escarpment which overlooks Mohawk River from the south.

8b. *The Catskill Section* of the Appalachian Plateaus is that portion in the northeast which rises with mountainous relief above the general level.

8c. *The Glaciated Section of the Allegheny Plateau* is that submaturely dissected portion of the Appalachian Plateaus whose topography is modified by glaciation.

8d. *The Conemaugh Section* (part of the Allegheny Plateau)[4] is that submaturely dissected portion of the Appalachian Plateaus which lies south of the glaciated section.

8e. *The Kanawha Section* (part of the Allegheny Plateau) is the maturely dissected middle portion of the province.

8f. *The Cumberland Section* of the Appalachian Plateaus is the southern portion of the province not yet maturely dissected.

9. **The New England Province** is the broad northeastward continuation of the Piedmont and Blue Ridge provinces, characterized by dissected peneplains with monadnocks.

9a. *The New England Upland* (section) is the non-mountainous part of the New England Province.

9b. *The White Mountain Section* of the New England Province is the area, including and adjacent to the White Mountains, characterized by abundant monadnocks.

9c. *The Green Mountain Section* of the New England Province consists of the linear mountain ranges having a granite axis.

9d. *The Taconic Section* of the New England Province is the belt of mountains and peneplain on the western border, whose

[3] Exact naming and possible subdivision of the Canadian portion is deferred.

[4] In the committee's report 8d is called the unglaciated section of the Allegheny Plateau and 8e (Kanawha section) is not expressly included in the Allegheny Plateau.

topography is conditioned by strong metamorphic rocks intricately deformed.

10. **The Adirondack Province** is an area of crystalline rocks of complex structure with a topography of subdued mountains bordered on the west by peneplain.

11. **The Interior Low Plateau Province**[5] is the dissected plateau (with included low plains) which lies west of and distinctly lower than the south end of the Appalachian Plateaus.

11a. *The Highland Rim Plateau* is the dissected plateau portion of the Interior Low Plateau.

11b. *The Lexington Plain* ("Bluegrass section" of Kentucky) is a local lowland developed on weak rocks.

11c. *The Nashville Basin* ("Bluegrass section" of Tennessee) is a local lowland developed on weak rocks.

11d. The unnamed section on the west is the low western extension of the Highland Rim Plateau characterized by silt-filled valleys and minor features due to faulting.

THE INTERIOR PLAINS embrace those portions of the interior of the continent which are characterized by small local relief, regardless of absolute altitude.

12. **The Central Lowland** is the relatively low eastern portion of the interior plains, being surrounded, except on the south, by provinces of greater altitude.

12a. *The Eastern Lake Section* is the area of broad cuestas and corresponding lowlands in which lie the basins of the Great Lakes and great lacustrine plains. It is characterized also by numerous morainic lakes in the younger glacial drift.

12b. *The Western Lake Section* is the area of young glacial drift and abundant morainic lakes and lacustrine plains west of the Superior Highland.

12c. *The Wisconsin Driftless Section* consists chiefly of an unglaciated area, but includes on the north and west a border of much eroded drift.

12d. *The Till Plains* are a section of the Central Lowland covered by glacial drift (regardless of age) characterized by nearly level surfaces without lakes and not yet dissected by streams.—This section consists of two subsections distinguished as older (Illinoian) and younger (Wisconsin).

12e. *The Dissected Till Plains* are that section of the Central Lowland which is covered by glacial drift of a formerly plain topography on which drainage systems are now well developed.

12f. *The Osage Plains* are the section of the Central Lowland which lies south of the glaciated area.

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[5] See footnote, pp. 32 and 59.

13. **The Great Plains Province** is the plateau which slopes east from the Rocky Mountains and the northern end of the Mexican Highland.

13a. *The Missouri Plateau* (glaciated) is that part of the Great Plains Province whose topography has been modified by the continental ice-sheets.

13b. *The Missouri Plateau* (unglaciated) is the northern section of the unglaciated Plains, from which the original sedimentary surface has been entirely stripped.

13c. *The Black Hills Section* consists of an eroded mountain dome bordered by residual monoclinical ridges.

13d. *The High Plains* are a north-south belt within the Great Plains, characterized by remnants of the former flat surface of sedimentation.

13e. *The Plains Border* is the eroded margin of the Great Plains east of the High Plains.

13f. *The Colorado Piedmont* is the western portion of the Great Plains in Colorado diversified and degraded by erosion.

13g. *The Raton Section* of the Great Plains is that portion in southern Colorado and northern New Mexico which is characterized by higher mesas and volcanic features.

13h. *The Pecos Valley Section* is that part of the Great Plains which lies between the Mexican Highland and the High Plains.

13i. *The Edwards Plateau* is the southern end of the Great Plains, not covered by the Tertiary formations which underlie the High Plains.

13k. *The Texas Hill Section* is the deeply eroded area lying between the young plateaus on the west and south and the lowlands on the east and north; a greatly-expanded and diversified phase of the Plains Border.

THE INTERIOR HIGHLANDS are the uplifted region in south central United States surrounded by lowlands.

14. **The Ozark Plateaus** comprise that portion of the Interior Highlands which is characterized by a plateau topography developed on nearly horizontal strata.

14a. *The Springfield-Salem Plateaus* comprise the non-mountainous, or less mountainous, portion of the Ozark Province.

14b. *The Boston Mountains* are a deeply-dissected plateau of mountainous relief rising above the Springfield-Salem Plateaus at the southern margin of the province.

15. **The Ouachita Province** is that portion of the Interior Highlands whose topography is conditioned by folded strata.

15a. *The Arkansas Valley Section* is the northern part of

the Ouachita Province whose topography is conditioned by gentle folds giving rise to low monoclinical ridges or cuestas.

15b. *The Ouachita Mountains* are that section of the Ouachita Province whose topography is conditioned by close folds subjected to baseleveling and to renewed erosion in one or more partial cycles.

THE ROCKY MOUNTAIN SYSTEM is a generally mountainous belt consisting of the northern and southern Rocky Mountain Provinces and the intervening Wyoming Basin.

16. **The Southern Rocky Mountains** comprise the continuous mountain system which lies (in the main) south of the Wyoming Basin. (To be divided into sections or ranges.)

17. **The Wyoming Basin** is an area of plateau, crossing the Rocky Mountain division, being continuous with the Great Plains on the east and the Colorado Plateau on the south.

18. **The Northern Rocky Mountains** comprise the continuous mountain system which lies (in the main) north of the Wyoming Basin. (To be divided into sections or ranges.)

THE INTERMONTANE PLATEAUS (southern division) embrace all the area west and south of the Rocky Mountain system in which mountains are either wanting or are isolated in relatively small ranges separated by desert plains. (A northern division of these plateaus lying almost wholly in Canada and Alaska consists largely of worn-down mountains. (See footnote p. 83.)

19. **The Columbia Plateau** is that part of the Intermontane Plateau division which is characterized by a substratum of nearly horizontal lava flows.

19a. *The Walla Walla Plateau* is that section of the Columbia Plateau which lies north of the Blue Mountains.

19b. *The Blue Mountain Section* of the Columbia Plateau Province is the mountainous area entirely surrounded by plateau surface.

19c. *The Payette Section* of the Columbia Plateau is the part west of the Snake River Plain whose substratum consists in large part of lacustrine sediments. (Applies to northern part only.)

19d. *The Snake River Plain* is a part of the Columbia Plateau distinguished by its very young lava plains.

19e. *The Harney Section* is that section of the Columbia Plateau which lies south of the Blue Mountains.

20. **The Colorado Plateaus** are a portion of the Intermontane Plateau division characterized by nearly horizontal strata greatly elevated and deeply eroded.

20a. *The High Plateaus of Utah* are a belt along its western margin consisting of exceptionally high plateaus, for the most part separated from one another by deep valleys or fault scarps.

20b. *The Uinta Basin* is a great north-sloping terrace of Eocene rocks abutting against the Uinta Mountains on the north and limited on the south by the south-facing Book Cliffs.

20c. *The Canyon Lands* section is that portion of the Colorado Plateaus south of the Book Cliffs which is deeply and intricately dissected by canyons.

20d. *The Navajo Section* of the Colorado Plateaus is a poorly-defined area of scarped plateaus in northeastern Arizona and northwestern New Mexico, less dissected than the Canyon Lands.

20e. *The Grand Canyon Section* of the Colorado Plateaus is that southwestern portion in which Carboniferous strata are exposed or locally covered by volcanic rocks.

20f. *The Datil Section* of the Colorado Plateaus is that southeastern portion whose topography is in large part determined by lava flows and other volcanic features.

21. **The Basin-and-Range Province** is that portion of the Intermontane Plateau division which is characterized by isolated, subparallel mountain ranges rising abruptly above desert plains.

21a. *The Oregon Lake Section* of the Basin-and-Range Province is the area characterized by young block mountains and lake basins.

21b. *The Nevada Basin* is a section of the Basin-and-Range Province, characterized by elevated desert plains and approximately equal areas of mountain and plain.

21c. *The Sonoran Desert* is a section of the Basin-and-Range Province characterized by the low level of its desert plains and the relatively small proportionate area occupied by its mountains.

21d. *The Salton Trough* is that depressed portion of the Basin-and-Range Province which is occupied, except at its northern end, by the Gulf of California.

21e. *The Mexican Highland* (in the United States) is a portion of the Basin-and-Range Province lying south of the Colorado Plateau, and characterized by elevated desert valleys and approximately equal areas of mountain and desert plains.

21f. *The Sacramento Section* of the Basin-and-Range Province is a belt on its eastern margin, whose mountains are in large part simple dissected cuestas.

THE PACIFIC MOUNTAIN SYSTEM consists of the contiguous mountain ranges and associated valleys bordering the Pacific Ocean.

22. **The Sierra-Cascade Mountains** are the continuous, approxi-

mately north-south chain at the eastern edge of the Pacific Mountain division.

22a. *The Northern Cascade Mountains* are the northern section of the Sierra-Cascade Province, the summits of which are in general, not formed by recent volcanic rocks.

22b. *The Middle Cascade Mountains* are that portion of the Sierra-Cascade Province whose height is due in part to volcanic accumulation and in part to crustal uplift.

22c. *The Southern Cascade Mountains* are that portion of the Sierra-Cascade Province whose height is due essentially to accumulation of volcanic materials.

22d. *The Sierra Nevada* is the southernmost section of the Sierra-Cascade Mountains, whose elevation is due to uplift and not to volcanic accumulation.

23. **The Pacific Border Province** is that portion of the Pacific Mountain division which lies west of the Sierra-Cascade Mountains.

23a. *The Puget Trough* is the intermontane lowland west of the Middle and Northern Cascade Mountains.

23b. *The Olympic Mountains* are the isolated group lying west of the north end of Puget Trough.

23c. *The Oregon Coast Range* is the section of the Pacific Border Province west of the Puget Trough and consisting of Tertiary rocks.

23d. *The Klamath Mountains* are the section of the Pacific Border Province adjoining the Cascade Mountains on the west and consisting of relatively old and resistant rocks.

23e. *The California Trough* is the intermontane lowland west of the Sierra Nevada.

23f. *The California Coast Ranges* are the mountains of the Pacific Border Province lying west of the California trough.

23g. *The Los Angeles Ranges* are the mountains of the Pacific Border Province which have an easterly trend and lie south of the Sierra Nevada.

24. **The Lower Californian Province** consists of the mountains and related valleys south of the Los Angeles Ranges.

Description and Interpretation of Boundaries.

Laurentian Highland.

As a major division lying mainly in Canada, the Laurentian Highland is a peneplain with local monadnocks, somewhat eroded after uplift, and thoroughly glaciated. Poor drainage is an almost universal characteristic so far as the region is known. Lakes and swamps abound and streams are relatively few. The prevailing thin-

ness of the glacial drift, except locally on the southern border, has caused the entire region to be frequently spoken of as the "rocky lake country." These general characteristics are so closely associated with the resistant pre-Cambrian rocks that the Laurentian Highland must be treated as essentially coextensive with the great continuous area of pre-Cambrian rocks around Hudson Bay.

Eastward from Lake Superior the boundary of the Laurentian Highland is boldly marked for more than 1,000 miles by the contact of pre-Cambrian with Paleozoic rocks. South and west of Lake Superior, the glacial drift is, for some distance, so thick that the nature of the underlying rock has no physiographic significance. From this region the boundary of the pre-Cambrian terrane turns north into Canada and is again accompanied by a contrast in the surface features on its two sides. On the accompanying map the boundary of the Laurentian Plateau east and south of Lake Superior is drawn at the edge of the pre-Cambrian terrane.

The Adirondack Province (p. 58) is geologically a part of the Laurentian division, but its physiographic features ally it more closely with the Appalachian Highlands. The neck connecting the Adirondack Province with the Laurentian Highland in Canada has, in the main, the topography of that great division, though near the St. Lawrence, it is inconspicuous because of small altitude.

The name *Superior Upland* is here applied, without a definite northern limit, to that portion of the Laurentian Highland which surrounds Lake Superior. In Wisconsin and the northern peninsula of Michigan, the fairly typical character of the province is represented here and there almost to its edge and the boundary line in this region is taken from the Willis Geologic Map of North America. In northeastern Minnesota the topography is highly characteristic, exhibiting peneplain, monadnocks, rocky lakes and imperfect drainage in typical form. In this state, however, the boundary of the Laurentian Highland is far from clear because of the thickness of the glacial drift on the borders of the pre-Cambrian terrane. The limits assigned to this province on the accompanying map are somewhat narrower than those of the pre-Cambrian area. The attempt has been made to separate in a general way the area whose topography is to some extent dependent on the pre-Cambrian rocks from the area in which the glacial drift is so thick that the topography is independent of the bed rock surface.

Atlantic Plain.

Landward Boundaries of the Coastal Plain.—The outer limit of the Atlantic Plain is the edge of the continental shelf. Its inner or landward limit is the inner edge of the Coastal Plain. The

coast line divides the Atlantic Plain into two provinces, the Coastal Plain and the continental shelf. The theoretical landward limit of a coastal plain is difficult to fix. In practice, however, there is general agreement concerning the inner edge of this one thruout the greater part of its length. By common agreement it is placed at the inner edge of the Cretaceous rocks, or of the Tertiary where the Cretaceous rocks are absent.

As to the northern limit of the Coastal Plain, usage is not uniform. If Long Island and other islands east of it, together with Cape Cod, are to be considered parts of the Coastal Plain, they are thereby (according to the definition given on page 36) assumed to be parts of an upraised continental shelf and to have an existence as land surfaces by reason of such uplift. If it be assumed that they are purely accumulations of glacial drift on the sea bottom, they are not technically coastal plain. A part of Long Island, at least, would certainly be above water even if the drift were all removed. This being the case, the whole island should be included in the province. It is not clear that the islands farther east and Cape Cod are essentially anything more than deposits of glacial drift on a shallow sea bottom, tho they contain some masses of Tertiary rocks. On the map here presented the Coastal Plain terminates with Long Island. The line from Long Island to Texas is a generalization of the above-mentioned geologic line as it appears on the Willis Geological map of North America. Between the 37th and the 40th parallels this boundary is known as the "Fall Line," being marked by rapids in most of the streams and by a considerably greater altitude of the country on its west side. Tho in part due to the differing strength of the rocks on its two sides, these features are believed to be emphasized by a fault or monocline whereby the Coastal Plain is depressed. In Missouri and Arkansas the Mississippi Alluvial Plain abuts against a similar steep slope.

The inner limit of Cretaceous and younger strata serves very well as a boundary for the Coastal Plain Province until Texas is reached. It fails there, partly because the Cretaceous extends far inland with a plateau topography, and partly because of the pronounced Balcones fault scarp, a feature which is inconsistent with the essential character of a coastal plain. This seaward-facing scarp is for several hundred miles a bold topographic feature and is here adopted as the inner boundary of the Coastal Plain. Thruout the greater part of its length this fault lies close to the boundary between the lower and upper Cretaceous outcrops. The former is the typical substratum of the adjacent plateaus. The latter is similar in its influence on the topography to the sediments elsewhere included in the Coastal Plain. From the point where the Rio Grande crosses the 101st meridian the scarp

extends east to the 98th meridian and north to Waco. There it becomes faint and the boundary line of the Coastal Plain is continued north to the Ouachita Province along the western edge of the Upper Cretaceous terrane, here marked by the "Eastern Cross Timbers" which separate the Grand Prairie on the west from the Black Prairie on the east.[6] The line on the accompanying map, so far as it follows the Balcones fault scarp, has been generalized from Hill's topographic map of the Texas Region.[7]

Sections of the Coastal Plain.—The northern (embayed or depressed) section of the Coastal Plain is here limited by an arbitrary straight line drawn across the province thru Cape Lookout. Neuse River marks the boundary approximately. The line which separates the Floridian section from its neighbors is even more arbitrary. The Floridian section is strongly characterized, but the zone of gradation is at least 50 miles wide. The lines which bound the Mississippi Alluvial Plain differ little from those given on the geologic map of North America. The effort has been made to extend the delta section just far enough east and west to include all distributaries with their attendant natural levees and delta lakes.

Appalachian Highlands.

Piedmont Province.—*Boundaries.*—The definition of the Piedmont Province (p. 37) necessarily fixes its western limit at the line where the plain or plateau topography gives way to one of mountains. Isolated mountains (like the Catoctins of Maryland and Virginia and the trap ridges of New Jersey) entirely surrounded by relatively level surface, are of course included in the Piedmont. Thruout the greater part of the boundary thus fixed there is not much room for difference of opinion as to its location. In New York, New Jersey and Pennsylvania the topographic break occurs along the line of contact between the weak Triassic of the Piedmont and the strong Cambrian and pre-Cambrian.[8] In Maryland and Virginia as far south as the Chesapeake and Ohio Railroad west of Charlottesville, almost all of that which appears on the Virginia geological map (1911) as pre-Cambrian granite and granite gneiss, belongs to the Piedmont, the boundary of the mountain area lying but little east

[6] R. T. Hill: Geography and Geology of the Black and Grand Prairies, Texas, *U. S. Geol. Surv.*, 21st Ann. Rep., Pt. VII.

[7] R. T. Hill: Physical Geography of the Texas Region, *U. S. Geol. Surv. Topographical Atlas*, Folio No. 3, 1900.

[8] Compare Geol. Map of Pa., *Pa. Geol. Survey*, 1893, with *U. S. Geol. Surv.*, Topographic Sheets.

of the strong Catoctin schist. This formation and the strong Lower Cambrian are the essential substrata of the Blue Ridge in this latitude. The same formations farther east make the Catoctins which are entirely within the Piedmont area.

South of Charlottesville and the Chesapeake and Ohio Railroad, geological contacts and contrasts seem to have nothing to do with determining the extent of mountain and plateau. The common boundary traverses a belt of crystalline rocks which are not differentiated on available geologic maps. The inner edge of the Piedmont has an elevation of about 800 feet just south of Charlottesville, but its altitude increases to 1,500 feet in southern Virginia, North Carolina and Georgia. A glance at most of the topographic sheets crossed by this boundary line is sufficient to show a contrast between the lower country with its gentler slopes and closely woven web of roads, and the mountain country with its closely crowded contour lines and absence of cultural features.

Bushy Mountain and South Mountain in North Carolina are essentially isolated mountain masses surrounded by the rolling Piedmont Upland; but they stand so close to the mountain province on the west that they might, with perhaps equal propriety, be considered as projections of it. As the boundary line is drawn on the accompanying map, the former course is adopted.

In northwest Georgia the number and size of outlying mountains on the edge of the Piedmont (Pine Log Mountain and others) is so great as to leave in doubt the propriety of terminating the mountain province at Coosawattee River or extending it southward to include Pine Log Mountain. The latter course has the advantage of precedent and is here adopted,[9] but the transitional character of this southern extension should not be forgotten.

In southeastern Pennsylvania where, for forty miles, the Blue Ridge is absent or represented only by isolated hills, there is little contrast in topography between the Piedmont and the Appalachian Valley which borders it. The line here used follows the contact of Triassic rock (typical of the northern Piedmont) and the older Paleozoic (typical of the Appalachian Valley Province).

In Georgia and Alabama south of the mountain province, the Piedmont is terminated on the west, not by a rise, but by a fall to the Great Valley. This break follows essentially the line of contact between the pre-Cambrian and Ocowee (Cambrian) series on the one hand and the younger and weaker Cambrian and Ordovician on the other.[10]

The topographic break along this line is easily traced westward

[9] C. W. Hayes: Physiography of the Chattanooga District, 19th Ann. Rep., *U. S. Geol. Surv.*, Pl. I.

[10] See Geological Map of Northwestern Georgia, *Georgia Geol. Survey*, Bulletin 23, 1910; also State Geological Map of Alabama.

from Georgia into Alabama. Turning southward again in the latter state, the topographic break becomes less clear. This is partly because of outlying ridges on the strong Chilhowee (Cambrian) series, these ridges being partly or wholly surrounded by the valley floor and separated geologically from the Piedmont by outcrops of the upper and softer Cambrian formations. Hence, in so far as the topographic break (and therefore the province boundary) can be referred to a geologic contact, it is drawn at the edge of the Ocowee outcrop. Farther north where the eastern boundary of the Great Valley is against the mountain province, the Chilhowee rocks and the mountains which they form are included in the area of the latter.

The remaining boundaries of the Piedmont on the east and south are all against the Coastal Plain.

Sections of the Piedmont.—The Piedmont Province is divided into two sections, the Piedmont Upland and the Triassic Lowland. The latter is mainly on the relatively weak Triassic rocks of New York, New Jersey, Pennsylvania, Maryland and Virginia, but it includes several small contiguous areas of Ordovician limestone. Among these limestone areas are the famous agricultural tracts of which Lancaster, Pa., and Frederick, Md., are the centers. The Piedmont Upland (see definition, p. 37) comprises the remainder of the province, underlain by strong rocks. At most places it is distinguished from the Triassic Lowland by greater altitude and deeper valleys, but south of the Potomac River the boundary is not topographically marked, the " upland " at that place, being but a narrow strip with low relief near the Potomac estuary.

Blue Ridge Province.—*Boundaries.*—The Blue Ridge Province embraces the Blue Ridge (range) and all the mountains contiguous with it. The boundaries of this division are well marked. At very few points along its boundary is there a zone of any considerable width whose reference to one province or the other might be in question. It embraces mountain country only, and is bordered by lower plateau country and valleys. The largest valleys within this mountain province can be comprehended in a single view and are seen to be surrounded by mountains. Isolated mountains rise also within the neighboring provinces, but they are entirely surrounded by the style of topography appropriate to those provinces. The boundary line on the accompanying map follows a topographic break, as traced on the large scale topographic sheets of the United States Geological Survey.

Thruout much of its extent this boundary line may be interpreted by noting its more or less close agreement with a geological contact. In such cases the logical description of the province is aided by using the line of contact as the province boundary, but it should be remem-

bered that the contact is used merely as a means of interpreting a line which has been fixed by other criteria. The western, or rather northwestern, boundary is thus determined thruout its entire length. For all practical purposes it agrees with the line where the stronger rocks of the pre-Cambrian or earlier Cambrian give way to the limestones and shales of the later Cambrian and Ordovician.

The boundary in Pennsylvania is a sharp topographic break, essentially at the contact of the "Cambrian Quartzite" shown on the geologic map of Pennsylvania (1893), with the Cambro-Ordovician rocks farther west. This is not quite equivalent to drawing the province boundary between the Georgian and the later Cambrian, since the topmost member of the former as mapped in the Mercersburg-Chambersburg Folio,[11] plainly belongs to the Great Valley. It is sufficient for the present to say that the quartzitic lower formations of the Cambrian, mapped by the Pennsylvania Survey as quartzite, lie within the mountain province and their contact with the weaker rocks on the west determines the province boundary.

Crossing into Maryland, the line continues to be determined, as in Pennsylvania, by the hard sandstone members of the Cambrian which underlie (stratigraphically) what is here as elsewhere mapped as Cambro-Ordovician. The Weverton sandstone is the chief one of these in Maryland.[12]

On the state geological map of Virginia (1911) the distinctively Cambrian formations (generally strong) are distinguished from the Cambro-Ordovician, consisting of limestone and shale. From the Potomac to the Tennessee boundary the topographic break between mountain and valley occurs at the contact between these strong Cambrian sandstones and quartzites on the east and the limestones and shales of the Cambro-Ordovician on the west. The line is closely followed in turn by Shenandoah River, by a part of New River, and by branches of the Holston. Thruout nearly the whole distance the Norfolk and Western Railroad (or its branches) runs parallel to the line thus indicated, always on the side of the limestone, and for more than half the distance it is less than five miles away from the contact.

In Tennessee the topographic break is likewise clear, as shown in the numerous folios of the United States Geological Survey. The older Cambrian, Ocowee and Chilhowee series, belong to the mountain province and the Knox Dolomite and younger formations to the Valley.* The same relations continue in Georgia where the Ocowee series is not differentiated from the granite on the most recent geologic map.[13]

[11] Geologic Atlas, *U. S. Geol. Surv.*, Folio No. 170.

[12] Cf. Maryland Geol. Map, 1906, with Harpers Ferry Topographic Sheet.

* See page 48.

[13] *Georgia Geological Survey*, Bulletin 23, 1910.

At about latitude 34° 30′ the mountain province ends. South of this the valley province is bounded by the Piedmont. The southern limit and eastern boundary of the mountain province have been described above (p. 47).

Sections of the Blue Ridge Province.—The two sections of the Blue Ridge Province (defined on p. 37) are separated with a fair degree of accuracy by Roanoke River. The northern section bears the name Blue Ridge (along with local names) thruout its entire length. This name is also applied to the main water-parting of the southern section, which follows the eastern edge of the province, but most of the mountains of the southern section bear other names. They are distinctly excluded from the Blue Ridge, tho included in the Blue Ridge Province.

Appalachian Valley Province.—*General Relations.*—The Appalachian Valley Province and St. Lawrence Valley together comprise a continuous series of depressions thruout the entire length of the Appalachian Highland. These two valley provinces merge in latitude about 43° 30′, tho at their juncture the valley is only three or four miles wide, and even this narrow passage is in part occupied by isolated hills related to the New England Province. The Appalachian Valley Province occupies a medial position in the Appalachian Highlands; the St. Lawrence Valley lies on the western flank of the Appalachian Highlands and is bounded on the west by the Laurentian Highland. The continuity of the Appalachian Valley Province is so striking that the exact locations of transverse boundaries between subdivisions are more or less arbitrary. While it is essential that this continuity be recognized, it is none the less necessary to divide the province into three sections for the discussion of its character.

Tennessee and Middle Sections.—The distinguishing characteristic of the Middle and Tennessee (southern) sections is a topography of parallel longitudinal valleys and mountain ridges made by erosion in the second (or later) cycle after folding. The middle section is also distinguished from the Tennessee section by having on its southeast side a broad belt which is characteristically free from mountain ridges. The two sections differ also in the plans of their ridges and valleys, those of the southern section being relatively straight, while many of the ridges of the Middle section, especially in its northern part, have a zigzag plan, thus enclosing canoe-shaped valleys. The master streams of the Tennessee section are longitudinal; those of the Middle section transverse. Aside from these differences, the two sections are much alike. The drainage pattern of both sections is in large part trellised.

The boundary between them is here placed at the divide between the Tennessee drainage system and that of New River.

These two sections are distinguished from the neighboring provinces by lines over which there can be little disagreement. The next province on the west has a plateau surface and, in general, dentritic drainage. The provinces on the east show so little parallelism of valleys as to suggest at once a more complex structure and rocks of different character.

The southeastern boundary of these sections separates them from the Blue Ridge Province and from the Piedmont. It has been traced and described in bounding those provinces. In eastern Pennsylvania, New Jersey and New York the boundary is against that extension of the New England Province which has been called the "Reading Prong," better known in New Jersey and New York as "The Highlands." It is marked by a perfectly clear topographic break and approximately corresponds in position with the contact of the pre-Cambrian with Paleozoic rocks. At its southwest end the Valley Province merges into the Coastal Plain with no sharp topographic contrast. For the sake of consistency elsewhere, the boundary line should follow the inner edge of the Cretaceous rocks.

The northwestern boundary of this part of the Appalachian Valley Province is the escarpment of the Appalachian Plateaus whose course is as follows: Beginning at the south in the vicinity of Birmingham, Ala., the eastern edge of the plateau is represented by Sand Mountain and after a short distance by Blount Mountain and farther north by Lookout Mountain. These are east-facing scarps of plateaus of Carboniferous Coal Measures. Lookout Mountain terminates at Chattanooga and the province boundary passes to the front of a more westerly plateau which bears the name Walden's Ridge. The east-facing scarp for a long distance north of Chattanooga is called the Cumberland Front.

Lookout Mountain is a large outlier of the plateau whose main portion lies to the west. It is entirely surrounded by valleys which are typical of the Appalachian Valley Province. But since the outlier is broad in comparison with the separating valleys, it is considered best to draw the boundary line around it, thus including in the plateau province the valleys of Wills and Lookout Creeks.

North of Chattanooga the boundary line follows the foot of Walden's Ridge and Cumberland Mountain and thus the edge of the Carboniferous rocks. The same line may be traced northward into Pennsylvania between the plateau capped by Carboniferous rocks (usually Coal Measures but locally Lower Carboniferous) and the valley underlain by older rocks. The scarp, tho locally absent in southern Virginia, is generally clear, and the contrast of elevation and topography

on the two sides is marked. The edge of the plateau bears in succession the names Sand Mountain, Blount Mountain and Lookout Mountain in Alabama and Georgia; Walden's Ridge and Cumberland Mountain in Tennessee and Kentucky; Stone Mountain, Rich Mountain and Allegheny Front in Virginia and West Virginia, besides numerous other local names. It overlooks in succession the valleys of Cahaba and Coosa Rivers in Alabama and Georgia; Tennessee River, Clinch River and its tributary Powells River, Bluestone and East Rivers (Pocahontas Quadrangle), Greenbrier River, Valley River, New Creek and Potomac River. The following railroads run essentially at the foot of the great scarp: the Alabama Great Southern south of Lookout Mountain, the Chattanooga Southern east of Lookout Mountain, the Cincinnati Southern from Chattanooga to latitude 36° (Harriman Junction), branches of the Southern Railroad from this point north to latitude 36° 20′ (the jog in the Briceville quadrangle), the Norfolk and Western along Clinch River and to latitude 37° 30′, and the Chesapeake and Ohio along the Greenbrier.

In Maryland the edge of the plateau is called Dans Mountain.[14] It overlooks Potomac River and its northern tributary Wills Creek. The foot of the escarpment is followed thru Maryland and north into Pennsylvania by branches of the Baltimore and Ohio Railroad. In western Maryland an extensive outlying plateau of Carboniferous (Pennsylvanian) strata is separated from the main plateau to the west by an anticlinal valley. This plateau whose eastern escarpment is called Dans Mountain is analogous to Lookout Mountain and is included in the Plateau Province for the same reason.

From the southern boundary of Pennsylvania north and east to the elbow of the Susquehanna east of Williamsport, the perfectly definite escarpment is known as the Allegheny Front. It is followed for forty miles by Susquenhanna River and for one hundred miles by the Bald Eagle branch of the Pennsylvania Railroad. Eastward from the west branch of the Susquehanna River the plateau surface is on the Pocono and Catskill formations and is essentially coextensive with these around the edges of the anthracite coal fields. The synclinal Wyoming Valley makes a long northeasterly extension of the valley province surrounded by steep inward-facing slopes. At Mauch Chunk the regular northeast trend is resumed, the scarp being formed first by the Pocono formation and then by the Catskill, overlooking Delaware River and in turn Neversink Creek, Rondout Creek and Hudson River. The Delaware and Hudson Canal and several railroads run close to the foot of the scarp.

The above described boundary lines, as shown on the accompanying map, are generalizations from the topographic sheets of the United

[14] See Geologic Map of Alleghany Co., Md., *Md. Geol. Surv.*, 1900.

States Geological Survey wherever such sheets are available. South of central Pennsylvania the boundary differs little from the edge of the Carboniferous as generalized on the Geological Map of North America. In New Jersey and New York as far north as latitude 42° 15′, the boundary on the accompanying map differs little from the edge of the Catskill formation as shown on the geologic map of New York.[15]

Hudson Valley.—The Hudson section of the Appalachian Valley Province is distinguished from the Middle and Tennessee sections by the absence of mountain ridges. In structure it is similar to the two sections farther south, but the folded strata are almost uniformly weak. Distinguished in this way, the Middle section ends with a fair degree of clearness at Hudson River, Shawangunk Mountain being the northernmost of the characteristic even-topped mountain ridges. The Hudson is therefore taken as the boundary. Between the Catskill Mountains and Hudson River is a continuous strip of lowland about six miles wide. Across this the section boundary must be drawn arbitrarily.

The plateau escarpment at the western edge of the Middle section continues northward as the eastern slope of the Catskill Mountains overlooking the Hudson Valley. East of this and near the river, the Helderberg formation makes a low cuesta. This cuesta with its east-facing scarp becomes higher toward the north, and beyong the parallel of 42° 15′ constitutes a distinct plateau which is here included in the Appalachian Plateaus Province. West of Albany the escarpment of this plateau turns west as the southern limit of the Mohawk Valley. Another east-facing scarp, however, continues north along the 74th meridian as the western boundary of the Hudson Valley. It does not correspond to any important geologic line, but it separates a lowland of 300 to 500 feet altitude from a dissected plateau 1,000 to 1,400 feet high. When followed northward this escarpment becomes less clear and merges with the eastern boundary of the Adirondack Province, which there limits the Hudson Valley on the west.

The eastern boundary of the Hudson section is against the Taconic section of the New England Province (p. 57). At the north the Hudson Valley section is continuous with the Champlain section of the St. Lawrence Valley Province. Near the low divide which separates the drainage of the two sections the valley is only three to four miles wide and interrupted by hills which have the character of the neighboring Taconic Mountains. On the accompanying map the two provinces are separated by a line crossing the valley at its narrowest point a little north of latitude 43° 30′.

St. Lawrence Valley.—The St. Lawrence Valley is an important province in Canada strongly individualized, its characteristic level

[15] Merrill: 1901.

plain abutting along most of its boundary against the highlands which surround it. Within the United States the St. Lawrence Valley is represented by the Champlain Valley and a narrow strip north of the Adirondack Mountains. The former constitutes a distinct section of the St. Lawrence Valley Province. Its boundary against the Adirondacks is marked by the contact of Paleozoic and pre-Cambrian rocks. The greater part of the eastern boundary is at the foot of the Green Mountains. This line agrees in the main, but not accurately, with the contact of Paleozoic and pre-Cambrian rocks. In its narrow southern extension the relation of the Champlain Valley to the Taconic Mountains on the east is the same as that of the Hudson Valley described above.

Appalachian Plateaus.—*Boundaries.*—The essential features of the Appalachian Plateaus Province are those of a dissected plateau, tho considerable areas in its southern portion are still in the youth of their erosion cycle. Except on its western side in Tennessee and adjacent states, all its boundaries are against other provinces which are *not* dissected plateaus. The southern half of its western boundary separates this province from the Highland Rim Plateau, which is likewise a somewhat dissected plateau, but so clearly distinguished by its lower elevation that popular usage has made the distinction in name and recognizes the same boundary which is used by geologists.

The absolute altitude of this province is not a criterion for its delimitation. Its uplands rise above 3,000 feet near the middle and fall as low as 500 feet at its southern extremity in Alabama, but the topography remains that of a more or less dissected plateau. Occasional folds give rise to certain local variations in topography which do not affect its general character. In general they are surrounded by flat-lying strata. Thus the province is characterized by a certain unity of structure and topography.

Thruout at least four fifths of its boundary this province is higher than its neighbors and is separated from them by an outward-facing escarpment. The best known escarpment is on the east side, where it is known in succession from north to south as the Catskill Mountains, the Allegheny Front and the Cumberland Front. No one system of rocks forms the plateau surface or makes the scarp everywhere. The upper Carboniferous is most general.

The southeastern escarpment of this province has been described as a boundary of the Appalachian Valley Province which it overlooks. The line was there traced from central Alabama to the Adirondack Mountains in New York.

The Appalachian Plateaus border on the Adirondack Mountains from longitude 73° 45′ (near Saratoga, N. Y.) to longitude 75° 30′.

In the eastern half of this boundary the Adirondack Province is distinctly higher than the plateau. The relatively weak strata which compose the plateau abut against the crystalline mass which makes the mountains. Thru most of the western half, the topographic relations are reversed. The Adirondack Province in this part is almost a peneplain and the plateau consists of a great southwest-sloping dissected cuesta, with its northeast-facing scarp locally 500 feet high, overlooking the Adirondack Province. At the foot of this scarp flows Black River which marks the province boundary. On its lower (southwest) side this cuesta grades into the Eastern Lake section of the Central Lowland. The boundary is not definite, but the character of the cuesta as a whole is strongly contrasted with that of the lowland to the west.

A short distance west of Utica the line which marks the western edge or foot of this dissected cuesta meets the east-west escarpment which is the northern limit of the Allegheny Plateau. This latter escarpment is approximately on the outcropping edge of the Helderberg limestone. Between this place and the point west of Albany mentioned on page 53, it does not deviate greatly from this geologic line. The outcrop of the Helderberg is the chief determining factor in the escarpment as far west as Oneida Lake where the edge of the Onondaga takes its place. This continues to Lake Cayuga. Between this lake and Seneca Lake the edge of the plateau shifts to the outcrop of the Portage sandstone which it follows to a point south of Buffalo. From the Mohawk Valley to Buffalo this escarpment was essentially the south shore of the Pleistocene lake at the time when the first continuous lake stretched from the Erie basin to the Mohawk.[16]

Between a point south of Buffalo and southern Ohio, the line here used as the limit of the Appalachian Plateaus follows no outcrop indicated on the geological maps of New York, Pennsylvania or Ohio. To a point in northeastern Ohio it lies within the Devonian and beyond that in the Lower Carboniferous. The line is described by Leverett[17] from the Genesee Valley to southern Ohio and is traceable on all the United States Geological Survey topographic sheets along its course, separating the somewhat dissected plateau on the south and east from lake flats and rolling plains on the north and west. South of latitude 40° 30′ the line lies near the edge of the glacial drift, but the thin edge of the latter generally overlaps the plateau, its edge almost following the western limit of the Pennsylvanian Coal Measures. It seems best, on the whole, however, to follow the line of the topographic

[16] H. S. Fairchild: *N. Y. State Ed. Dept.* Bull. 519.

[17] Frank Leverett: Glaciation in the Erie and Ohio Basins, *U. S. Geol. Surv. Mon.* 41, p. 67. A part of the plateau, in Northeastern Ohio is so characterized by glacial features that it might perhaps better be included in the Eastern Lake Section of the Central Lowland.

break a little farther west, since neither the edge of the Coal Measures nor that of the drift could be followed far either north or south.

From Chillicothe, Ohio (latitude 39° 15′) southward, the topographic break agrees essentially with the Carboniferous-Devonian contact. This contact is therefore taken as the province boundary as far south as the Kentucky River. At that place the western edge of the Carboniferous is also essentially the western edge of the Coal Measures. North of that point the topography on the narrow strip of Lower Carboniferous is not materially different from that of the Coal Measures on the east. South of that point the western edge of the Coal Measures is marked by an increasingly bold escarpment which separates the Cumberland Plateau (Pennsylvanian) from the Interior Low Plateau (Mississippian). The province boundary follows this contact southwest and then west to the boundary of the Coastal Plain.

Sections of the Appalachian Plateaus.—The sections of this province are distinguished in some cases by altitude, in others by degree of dissection. The main portion of the Mohawk section is a strike valley at the foot of the Helderberg-Onondaga escarpment. The ends of this valley are lowlands and belong to other provinces, but between Utica and Schenectady the Mohawk is entrenched in a dissected plateau, a part of the Mohawk section. The northwestern extension of this section is, as stated above, a dissected cuesta which rises to a maximum altitude of 2,000 feet.

The name Allegheny Plateau is applied to all that part of the province which lies between the Helderberg-Onondaga-Portage escarpment on the north and the Cumberland Plateau or "Cumberland Mountains" on the south. The application of the name would thus be extended south almost to the Kentucky-Tennessee boundary. This great area is here divided into three sections in addition to the Catskill Mountains. The latter are merely an extra high portion of the plateau. The Catskill section is almost coextensive on its north and east sides with the strong Catskill conglomerate. On the south and west sides the same strata are much more extensive but less elevated.

The three sections of what is customarily called Allegheny Plateau are distinguished as the Glaciated section, the Unglaciated or Conemaugh section and the Kanawha section. In its characteristic aspect the Glaciated section is distinctly different from the Conemaugh section, but the boundary between the two is not everywhere sharp. In northeastern Pennsylvania the topographic effects of glaciation disappear gradually over a wide transitional zone. Both this section and the Conemaugh section have considerable areas which have not yet reached maturity in the present erosion cycle. They differ in this respect from the Kanawha section which is everywhere maturely dis-

sected and has, in general, a greater altitude. The northern limit of the Kanawha section is, however, very vague.[18]

The Cumberland section is the least dissected of all. It is characterized by broad uncut remnants between deep valleys. Toward the southwest this character gives way to milder relief.

New England Province.—*Boundaries.*—The New England Province is in a sense the northeasterly continuation of the Piedmont and Blue Ridge provinces. It is allied to them by the general strength of its rocks. Like them, also, it is bounded on the west by the Appalachian Valley Province.

The western boundary of the New England Province (within the United States) is determined thruout by the strength of its rocks. The line which separates it from the Champlain Valley is not far from the edge of the granites which constitute the Green Mountains, tho some resistant metamorphic rocks are included with them in the Green Mountain section. The strata which underlie the Hudson Valley are generally weak (p. 53). East of the valley these same strata and others have been profoundly metamorphosed and thus rendered resistant. They are now almost as uniformly strong as those of the Hudson Valley are uniformly weak. These strong rocks are the substructure of the Taconic Mountains, the westernmost section of the New England Province. As the transition from the shale of the Hudson Valley to the slate and schist of the Taconic section is not abrupt, neither is the contrast in topography at all places sharply marked, but the transition zone is nowhere broad. At most places an observer in the valley may see a distinct range or escarpment to the east.

Sections of the New England Province.—The Taconic section is mainly a belt of low mountains. Thruout much of its length the western margin of the section is an uplifted and dissected peneplain called the Rensselaer Plateau. On account of intense compression, the rocks of this section (formerly in large part shale) are slates and schists without regular alternations of strong and weak strata. Conspicuous straightness and parallelism of ridges and valleys are therefore wanting. The crests of the Taconic Mountains do not suggest a dissected plateau, but, as stated above, a part of the belt is occupied by the Rensselaer Plateau, an uplifted and dissected peneplain. East of the Taconic Mountains is a long, continuous and well-marked valley drained by Housatonic River at the south and Otter Creek at the north. This valley, largely eroded on limestone between the Taconic Moun-

[18] On the accompanying map this boundary is indicated by a nearly straight line of dashes indicating that there is no sharp distinction. It may well be that the areas thus separated should have been made divisions of a lower order rather than sections.

tains on the west and the Green Mountains on the east, is included in the Taconic section, the boundary being placed at the west of the Green Mountains and their southern extension.

Sufficient data are not yet available to make it possible to draw the outlines of the remaining sections of the New England Province. At least three other sections must be recognized: the Green Mountain section, the White Mountain section, and the New England Upland. In the Green Mountain section are included the southward extension of these mountains in the "Berkshire Hills" of Massachusetts and Connecticut. This section is essentially a linear range rising above the neighboring plateau. It may, as in Vermont, consist of a continuous monadnock ridge, or, as in Massachusetts, of dissected remnants of higher peneplains, themselves surmounted by occasional monadnocks. The location and general extent of the section are indicated on the geologic map by a belt of pre-Cambrian rocks, but the section extends somewhat beyond the limits of these rocks.

The White Mountain section is simply an area of closely crowded monadnocks centering in northern New Hampshire. As these are separated by portions of the New England Upland and their separation grows wider and wider with increasing distance from the center of the section, the delimitation of this section must necessarily be arbitrary. Its characteristics are very real and important, but its boundaries are vague.

The largest section is the New England Upland which consists essentially of an upraised and dissected peneplain, whether of one cycle or of several. Considerable areas within it have been cut down to lower levels and contain few or no remnants of the peneplain which makes the plateaus. Such areas may be underlain by weak rocks (e. g., the lower Connecticut Valley), or may lie near the seaward margin of the province (e. g., the Boston Basin). In future and more refined studies it may be feasible to subdivide the New England Upland on the basis of erosion cycles. The area of Triassic rocks which agrees in the main with the lower Connecticut Valley should probably be made a division of lower order. It is in all essential respects an outlying portion of the Triassic Lowland included in the Piedmont Province.

Adirondack Province.—The boundaries of the Adirondack Province have already been stated in describing those of neighboring divisions. The distinctive topography of this province is due to the crystalline rocks which compose its substratum. In general, these are stronger than the Paleozoic rocks which surround them; hence the Adirondack Mountains. In the western part, however, mountains are wanting and the adjacent plateau rises 500 feet above the Adirondack Province.

Geologically this province might be called a peninsula of the Lau-

rentian Highland with which it is connected by a narrow neck of crystalline rocks. Topographically, it is more like the White Mountains and others of New England, and it seems to have shared the physiographic history of the Appalachians more than that of the Laurentian Highland.

Interior Plains.

Interior Low Plateau.[19]—*Features of the Province.*—This province lies west of, and distinctly lower than, the southern part of the Appalachian Plateaus. It has been known as the "Interior Lowlands,"[20] but the portions which may strictly be called *lowlands* are essentially isolated even tho very important. The rest is typical plateau, even tho in the western part the uplands and divides have an altitude of only about 500 feet. The altitude on the eastern side is about 1,200 feet. East of the Nashville Basin in Tennessee, where dissection is submature, the plateau is known as the Highland Rim, but the country thus designated grades without a break into the lower and maturely dissected upland of southern Indiana and Illinois and western Kentucky. Its essential plateau character is continuous even tho the summit levels decline gradually to about 500 feet. Within this area are two basins (the Nashville and the Lexington) which are recognized as sections.

Boundaries.—The boundaries assigned to the province are as follows: Beginning in southern Ohio where the edge of the glacial drift intersects the western edge of the Carboniferous rocks, the province boundary is traced south along this western edge of the Carboniferous to Kentucky River. South of Kentucky River the boundary between the Interior Low Plateau and the Cumberland Plateau is the escarpment at the western edge of the Coal Measures. This line is a bold

[19] The committee which devised the accompanying map and classification of divisions, has not yet reached unanimous agreement concerning this province, Messrs. Campbell and Matthes believing that the eastern part should be included in the Appalachian Highlands. The Highland Rim, strictly so called, is that part of the province which lies east of the Nashville Basin. Generally speaking this is higher and less dissected than the plateau farther west. Moreover, it is separated from the latter by the Nashville Basin except for short distances in southern Kentucky and northern Alabama. Hence, if any portion of this province is to be included in the Appalachian Highlands, the one feasible plan seems to be to allot this eastern strip to the Appalachians, making it a part of the Cumberland section or a section by itself. This would preclude the use of the name "Highland Rim" for the province on the west. On this account the name "Interior Low Plateau" already applied to this province in a former publication is here provisionally retained. It is technically correct though cumbersome. The use of the name Highland Rim Plateau for a section of the province is open to the same objection, tho to a less degree. No satisfactory substitute has been found even for provisional use.

[20] C. W. Hayes: Physiography of the Chattanooga District, *U. S. Geol. Surv.*, 19th Ann. Rep., Pt. II.

one in Tennessee, less bold but still adequate in Kentucky, but faint in northern Alabama where the Cumberland Plateau itself is low. Stream erosion has made the boundary very irregular. In the mapping of large areas it is necessarily generalized.

In northwestern Alabama the low plateau borders the Coastal Plain along the Carboniferous-Cretaceous contact. This line is ragged and indefinite and is marked by no abrupt change in elevation or topography. On the plateau side (northeast) the Cretaceous appears in isolated patches capping hills and uplands. These should be allotted to the plateau. On the side of the Coastal Plain the Carboniferous appears only in stream valleys. Such should be counted in the Coastal Plain. The transition belt is thus narrowed to a few miles. Within this zone are many points where the contrast is sharp, being expressed in topography, or soils, or in both.

In western Tennessee and Kentucky this province borders the Coastal Plain, the line being the Paleozoic-Cretaceous contact. For practical purposes Tennessee River may be considered the boundary. The same contact is followed west thru southern Illinois to the Mississippi. Northward from the point thus reached, to the edge of the glacial drift, the Mississippi is taken as the boundary between the Ozark Province and the Interior Low Plateau.

Eastward from the Mississippi the edge of the glacial drift constitutes the boundary between the Till Plains on the north and the Interior Low Plateau on the south.[21] Its general course is eastward to the Allegheny Plateau. East of Louisville it does not deviate much from the course of Ohio River, but west of that it bends far northward around southern Indiana which has a topography like that of Kentucky west of the Lexington (Blue Grass) Plain. The edge of the drift is not sharply marked. Locally the drift thins out gradually thru a zone of twenty miles or more.

Sections of the Interior Low Plateau.—The two lowland sections within the Interior Low Plateau comprise the areas of rock older than Carboniferous. The edge of the latter forms an escarpment, locally frayed and irregular, entirely around the Nashville Basin and around the Lexington Plain on the east and south. Thruout practically its entire extent this escarpment is plainly visible as a range of hills, when viewed from the basin floor. The northern boundary of the Lexington Plain is the edge of the glacial drift, that is, the outer boundary of the province. The plateau between and around these two basins is the Highland Rim Plateau or section. The western end of the province, beside being lower, shows local topographic effects of faulting and also of valley filling. It is probable that these features

[21] See map by Leverett; *U. S. Geol. Surv.*, Mon. 38, Pl. VI.

justify the recognition of a distinct section, tho the necessary data for determining its boundaries are not available.

Central Lowland.—*Boundaries.*—An irregularly shaped region stretching north, south and east from central United States, is essentially a low plain. It is in the main bounded by lands which are either not low or not plains. The northern, eastern and southern boundaries of this province have already been described thruout most of their extent. The Central Lowland extends far north into Canada with boundaries similar to those which prevail in adjacent parts of the United States.

The separation of this province from the Great Plains Province on the west is made necessary, not so much by the boldness of the dividing line as by the contrast in general character between the two areas. The Great Plains are described on page 67. The Central Lowland, while not now at its local baselevel, is nevertheless characterized by relative lowness and relative levelness. Large areas adjacent to the Great Plains, especially in the southern part, are peneplain. The boundary line between these two provinces, not itself a bold topographic feature, is, thruout most of its length, an east-facing escarpment. While but a few hundred feet high, the streams which cross this escarpment generally find themselves on its east side not very far above their local baselevels. The surface west of the escarpment is a few hundred feet higher and actively dissecting.

Beginning in North Dakota, the Plateau of the Missouri (not the Missouri Coteau but the plateau on which the latter rests) terminates on the east, or northeast, in an escarpment 300 to 400 feet high. Thru most of its length of more than 300 miles in North Dakota, railroads follow the foot of this escarpment. On one side of the line lie the fertile prairies of North Dakota, adapted to farming; on the other, above and beyond the escarpment, the high grazing lands of the Altamont moraine, the real Coteau of the Missouri. The line here used is taken from the reconnaissance soil map of western North Dakota.[22] The topographic break is shown very clearly on the Edgely and adjacent topographic sheets of the United States Geological Survey. Continuing into South Dakota the line becomes less clear. It is nowhere far from the Missouri-James divide.[23]

In Nebraska alone, the line is almost wholly arbitrary. Between typical low Prairie on the east and typical Great Plains on the west there is complete gradation with no abrupt change of altitude or style of topography. Neither bed rocks nor glacial drift are topographic factors of importance, for both are buried by loess whose maximum depth reaches sixty feet. However, since the line in the Dakotas is

[22] Field operations of the Bureau of Soils, *U. S. Dept. Agri.*, 1908, Plate 33.

[23] The data for the location of this boundary were furnished by N. H. Darton.

plain and a similar line in northern Kansas equally plain, and the edge of the glacial drift in Nebraska (so far as determined)[24] is essentially in line with the escarpments in South Dakota and Kansas, this line, the edge of the glacial drift, is arbitrarily taken as the boundary in Nebraska.

In northern Kansas the outcrop of the Dakota sandstone forms a rugged belt known as the Smoky Hills, reaching from the Nebraska line almost to the Arkansas River. This line of the Smoky Hills, the eastern eroded margin of a highland which is continuous toward the west, is the natural western boundary of the Central Lowland.

The eastern margin of the hilly belt is, of course, frayed and irregular, but forms a typical natural boundary between contrasted topographic types from the Nebraska line southward to the center of Kansas; that is, to a point not far west of McPherson. Fifty miles straight south of this point a similar contrast is found, the low plain on the east being uninterrupted, though its altitude declines southward. On the west is a dissected upland called the Red Hills, its substructure being of the Permian "Red Beds." The ragged escarpment is 300 to 400 feet high.[25] With diminishing dissection toward the west, and increasing remnants of the Tertiary cover, the Red Hills merge into the High Plains.

The break of fifty miles in Kansas, alluded to above, is due to a westward extension of level prairies along the Arkansas River, known as the Great Bend Lowland.[26] It is a smooth surface rising to the westward and is quite as high on any one meridian as the crests of the Smoky Hills upland on the north and the Red Hills upland on the south. It is not a lowland in the sense of lying near sea level, being 1.500 feet high on the east and rising steadily to 2,300 feet on the west. Neither is it low by comparison with neighboring areas north and south. It is a lowland only in the sense of being near to its own local baselevel, for the Arkansas has been unable to entrench itself here, probably because of the strong rocks crossed farther east. The parallel streams on the north and south have cut their channels from 100 to 300 feet lower on the same meridians. Their tributaries have therefore dissected into "Smoky Hills" and "Red Hills,"—the plateau which here remains as the "Great Bend Lowland."

This level prairie, being agriculturally favored, is commonly thought of as an arm of the Central Lowland extending into the Great Plains, but its topography and geologic history are those of the Great Plains. (See below under that subject.) Indeed, all but a narrow strip along the river is an eastward peninsula of the High Plains (the central

[24] See Todd; *U. S. Geol. Surv.*, Bull. 158, Pl. 1; also *Science*, Feb. 20, 1914.

[25] Gannett: Contour Map of Kansas, *U. S. Geol. Surv.*, Bull. No. 154.

[26] Geo. I. Adams: Physiographic Divisions of Kansas, *Bull. Amer. Geogr. Soc.*, Vol. XXXIV, pp. 89-104.

division of the Great Plains), having been here saved from erosion by the inability of the Arkansas to erode deeply because of the disadvantage mentioned above.

Whether this "Great Bend Lowland" be included in the Central Lowland or in the Great Plains, there are difficulties in drawing the boundary. On the whole, it seems best to include it in the Great Plains where it naturally belongs by reason of its geologic and physiographic history. Otherwise, arbitrary boundaries on the north and south must be selected. Its separation from the Central Lowland on the east must also be by an arbitrary line. However, if the two free ends of the well-established boundary be connected by a straight line across the fifty-mile gap in southern Kansas, the resulting line will not be far from the eastern edge of the Cretaceous and Tertiary rocks, both highly characteristic of the Great Plains.

It is worthy of note, also, that even from an agricultural point of view the western end of the Great Bend Lowland differs quite as much from the typical prairies as the eastern end does from the border of the Great Plains.[27]

East of the meridian of 97° west longitude, and entirely surrounded by typical prairie of the Central Lowland, is a north-south belt called the "Flint Hills," extending northward from northern Oklahoma about halfway across the state of Kansas. This belt has been described by Adams[28] as belonging to the Great Plains Province. The character of the belt would justify this, but it is impossible to connect it with that province without including in the same boundary almost an equal area of the most typical prairie lowland. It seems better to describe the Flint Hills as a local feature, as must be done for the Wichita Mountains in Oklahoma, the Turtle Mountains in North Dakota and many other exceptional features.

South of Kansas the Red Hills escarpment is known (for reasons implied in the name) as the Gypsum Hills escarpment.[29] In general, it is the dissected edge of a western upland overlooking to the eastward the prairies of small relief which lie too near their local baselevel to be sharply dissected. In its southern extension this line lies very close to the boundary of the distinctively Great Plains flora, as mapped by Hill in his Physical Geography of the Texas Region.[30]

It is thus seen that thruout the six states traversed by the eastern boundary of the Great Plains, the line in four of these and a part of the fifth (Kansas) is satisfactory. It has geological significance, conforms to popular usage and is marked by a topographic contrast within

[27] See Report of Thirteenth Census, Vol. IV, p. 554, map.

[28] Geo. I. Adams: *loc. cit.*

[29] B. Franklin Wallis: Wapanucka Limestone, *Okla. Geol. Survey*, Bull. 23, 1915.

[30] Topographical Atlas, *U. S. Geol. Surv.*, Folio No. 3, 1900, Fig. 18.

a narrow belt. The satisfactory character of three-fourths of the entire line justifies the somewhat arbitrary character of the remaining fourth. The actual location of the boundary, especially near the south end, is capable of further refinement as more exact data become available.

Driftless Sections of the Central Lowland.—The Central Lowland is subdivided into sections on the basis of features due to glaciation. Locally, as in Wisconsin, there appear clearly marked subdivisions determined by the underlying rocks, but the lines which are clearly marked in this state are serviceable for only a short distance beyond its limits. The use of such lines would therefore leave the major part of the province undivided, whereas its several parts are clearly distinguished on the basis of glacial features. On this basis the most evident distinction is between drift-covered and driftless. Two of the sections are driftless or nearly so. One of these, the Osage Plains, lies south of the southern limits of glaciation. It is separated from the Dissected Till Plains to the north by a line following approximately the course of Kansas River. This line is not a bold one, for the drift on the north is thin and very much eroded. Furthermore, a covering of loess on both sides of the line reduces the contrast still further.

The Wisconsin Driftless section lies three hundred miles north of the southern limit of glaciation and is entirely surrounded by drift-covered areas. The essential topographic feature of this area is its dissected plateau character. Its topography is not unlike that of western Kentucky. In the northern part of this area the valleys have been filled by outwash, making plains of such wide extent that the hilltops rise above them as isolated buttes. The contrast with the lake section on the east is sharp, the boundary being marked by the front of the late Wisconsin terminal moraine, one of the boldest terminal moraines on the continent. On the other sides the boundary line is indefinite. On the west and north are margins of old and much eroded drift. Their topography is much more like that of the Driftless Area than like that of the neighboring sections. It is partly for this reason, but largely because the areas are too small to justify their recognition as independent sections, that they are included in this section. For the purpose here in hand the Wisconsin Driftless section is made to cover essentially the area whose topography is not affected, or but little affected, by glacial drift.

Lake Sections of the Central Lowland.—East and west of the Wisconsin Driftless section are two large sections of the Central Lowland whose topography is dominated by recent glaciation in a region of moderate relief. Terminal moraines, with their various features; ground moraines embracing mildly rolling plains, rounded and veneered hills; outwash plains, in some cases profusely pitted; broad lacustrine

plains: these occupy most of the area. Lakes and swamps of glacial origin are numbered by the thousand, and include four of the Great Lakes. On the whole the drainage is poorly developed.

Some of the features of the Lake sections are shared with the Laurentian Highland. On the whole the glacial drift in the former is much thicker than in the latter. The proportion of relief due to the drift and not dependent on the underlying rock is much greater here than in the Laurentian Highland. For many purposes, especially geographic, it may be convenient to group the two lake sections with the Superior Upland, thus approximately restoring Powell's "Lake Plains."[31]

On its northern side the Eastern Lake section borders on the Laurentian Highland along the line already described. On the west it ends with the bold terminal moraine of the late Wisconsin glacial stage. West of this lies the Wisconsin Driftless section and farther south the Till Plains.

The separation of the Eastern Lake section from the Till Plains is based purely on the topography of the drift. Thruout a considerable part of the boundary the drift on its two sides is of the same age, but the contrast in topography is marked. Thru northeastern Illinois the line on the accompanying map follows the outer edge of the late Wisconsin moraines.[32] South of Kankakee River these moraines form the western rim of the Kankakee swamp. On the southern margin of this great swamp the line turns east to Logansport, thence it follows Wabash River to Fort Wayne.[33] East and north of the line thus described the surface is characterized by morainic topography, lakes, swamps, and lacustrine plains.

East of Fort Wayne is the lacustrine plain of glacial Lake Maumee. Plains of this kind are important constituents of the two lake sections. They are found on the border of all the Great Lakes and are allied to them in history. The boundary of the Eastern Lake section runs east from Fort Wayne along the southern shoreline of glacial Lake Maumee to the point where that line intersects the boundary of the Appalachian Plateaus near Cleveland. The boundary between the latter and the Eastern Lake section, while not determined by the former extent of the Great Lakes, is nowhere far from the edge of the lacustrine plains.

The Western Lake section borders on the Superior Upland and the Great Plains along lines already described. Its southern boundary, west of central Iowa, is the outer edge of the drift of the Wisconsin glacial stage. Generally within a very few miles a clear contrast may

[31] J. W. Powell: *Nat. Geogr. Monographs*, No. 3, 1896.

[32] Frank Leverett: The Illinois Glacial Lobe, *U. S. Geol. Surv. Mon.*, Vol. XXXVIII, Pl. VI.

[33] Charles R. Dryer: Studies in Indiana Geography, p. 19.

be observed between the rolling (at places morainic), little eroded and poorly drained country on the north, and the much eroded Till Plains on the south. Its boundary against the area of Iowan drift in northeastern Iowa is discussed below.

The northern portion of the Western Lake section includes the vast lacustrine plain of glacial Lake Agassiz, most of which is in Canada. It is represented in the United States by the broad and very flat valley of the Red River of the North.

Till Plains Sections of the Central Lowland.—The character of the Till Plains (not the Dissected Till Plains) is implied in their name. Their surface is characteristically (tho not universally) plain and topographically young. There are some morainic ridges, but they are relatively narrow and low and without lakes. In many cases they are so low and of such gentle slope that their presence is revealed chiefly by their control of drainage lines (as in eastern Indiana). Without this indication, some of them would not be detected by the unaided eye. Exceptions to its general character are found in a few strong moraines, particularly those of Illinois north and east of the center of the state. But even here glacial deposition was not of such a character as to produce lake basins. In a comprehensive view the country has the aspect of a plain.

With respect to absolute age and to geological history, the southern and western margins of this section are older than the rest. As these are also the sides on which large rivers have cut their valleys, these edges are in places much eroded, but nowhere is it necessary to go back more than a few miles from these large streams to find remnants of the original flat surface.

Except on the west, the boundaries of this section have already been described. They lie in succession against the Wisconsin Driftless section, the Eastern Lake section, the Appalachian Plateaus and the Interior Low Plateau. The boundary between this section and the Ozark Plateaus is essentially at the Mississippi. North of the Ozark Plateaus the western boundary is at the contact of the Illionian and Kansan drift sheets. In practice it is best to follow the Mississippi River as far north as Iowa. Farther north the Till Plains cross the Mississippi into Iowa. Here their limit is marked merely by the greater amount of erosion which the country on the west has suffered.

The Dissected Till Plains, separated from the Ozark Province by the Missouri River, are coextensive with the drift of the Kansan and Iowan glacial stages where not covered by later deposits. The topographic character is implied in the name given to the section. Remnants of plain surface, perhaps one-fifth of the total area, indicate by their uniformity of altitude that the region in its topographic youth was like the Till Plains on the east and not like the Lake sections on the north.

The area covered by the Iowan drift sheet in northeastern Iowa is included in this section because its topography resembles that of the Kansan drift to the south rather than that of the Wisconsin drift to the north. The eroded surface of the former was overridden by the ice of the relatively recent Iowan glacial epoch and a thin mantle of new drift was deposited but the topographic effects were not great.*

Great Plains Province.—*General Relations.*—Between the Rocky Mountains and the Central Lowland is a great eastward-sloping plateau, universally known as the Great Plains. The area which is topographically related to these plains is somewhat greater than the one commonly designated by the name, but the term Great Plains is more distinctive of the entire area than any other that might be chosen.

The unity of this large region consists in its plateau character. It is thus sharply distinguished from the mountains on the west and, for the most part, satisfactorily delimited from the low plains on the east. It is conceded to be impossible to distinguish plateau from low plains on the basis of mere elevation above sea-level. The characteristics are always more or less relative, but the underlying thought is that a plateau, if not already dissected, lies high enough above base-level to admit of sharp dissection while a low plain does not. Consciously or unconsciously this *principle* underlies our distinctions, but to give an exact rule for the use of these terms may be impossible. This is the principle borne in mind in determining the boundary between the Central Lowland and the Great Plains. It has already been shown (p. 61) that, thruout the greater part of its length, this province is separated by a natural line (generally a dissected escarpment) from the Central Lowland on the east.

Boundaries.—It is unnecessary to describe in detail the boundary line between the Great Plains and the mountains on the west. If drawn in the field by various observers the several lines selected would nowhere diverge more than a few miles. For most of the distance the boundary is approximately at the contact of Mesozoic and younger rocks on the east with Paleozoic and older rocks on the west. At the immediate foot of the mountains these younger rocks are generally upturned, the harder strata forming foothills of the hogback type. Generally the first prominent ridge of this kind encountered in approaching the mountains should be taken as the boundary. Where such foothills are not present, as in the Lewis Mountains in northern Montana, and locally in the Bighorn of Wyoming and the Sangre de Christo of Colorado, the rise from the plain is generally so abrupt that the boundary may be drawn with sufficient accuracy on the United

* Frank Leverett and Wm. C. Alden,—personal communications.

States Geological Survey contour map of the United States. (Scale 40 miles to 1 inch.)

The criteria here given suffice for the tracing of the province boundary southward from Canada at the foot of the Lewis Mountains, and eastward around the Big Belt and Little Belt Mountains in Montana. South of the Little Belt Mountains the real mountain front swings 50 miles westward to the Bridger Range on the 111th meridian, and then again eastward at the northern base of the Snowy and Beartooth Mountains which border the Yellowstone Plateau on the north. This great embayment of the mountain front is partially occupied by the Crazy Mountains, an isolated mass similar to other volcanic centers on the Great Plains. South and west of the Crazy Mountains is a strip of valley, continuous with and resembling the Great Plains, but north of these mountains the valley is high and rough. It seems best, therefore, to include the Crazy Mountains in the northern Rocky Mountain Province. The province boundary on the accompanying map is therefore drawn at their eastern base.

In a similar manner, after skirting the Beartooth Plateau, the province boundary is made to cut arbitrarily across the mouth of the Bighorn Basin (40 miles) to the end of the Bighorn Range. The Bighorn Basin is thus treated as a feature of the mountain province, similar to some other basins smaller than this which are entirely enclosed by mountains.

From north to south along the foot of the Bighorn Mountains the line is determined both geologically and topographically within narrow limits. South of that for forty miles the Great Plains must be arbitrarily cut off from a similar plateau, the Wyoming Basin. This cut-off is inevitable, as it is impossible to treat southwestern Wyoming and northwestern Colorado as an extension of the Great Plains. The line from the Bighorn Range to the Laramie is described on page 80.

Along the Laramie Mountains of Wyoming, the Rocky Mountain Front Range in Colorado, and the Wet Mountains south of the Arkansas River, there are few breaks in the line of hogback foothills. The province boundary is thus well marked. The line as here drawn passes behind Huerfano Park (southwest of the Wet Mountains) allotting it to the Great Plains. It likewise passes west of the Spanish Peaks which are isolated volcanoes east of the Rocky Mountains, and continues southward between the horizontal strata of the Plains (late Cretaceous and early Tertiary) and the upturned strata of the foothills (Cretaceous and Carboniferous). The lines on the accompanying map follow as nearly as possible the geologic map of Colorado (Colo. Geol. Surv., 1913). Some uplands above 8,000 feet are thus assigned to the Great Plains Province. The equally high Ocate Plateau (lavas) to the south is part of the same province, the line following, as before,

the hogbacks of Cretaceous and Carboniferous rocks on the west of the volcanic plateau south to latitude 35° 30′. Approximately at that place the mountains on the west come to an end and the Great Plains are interrupted by a great east-west escarpment from which the Las Vegas Plateau (Cretaceous) on the north overlooks the Pecos Valley (Triassic) on the south.

The Pecos Valley, a highly characteristic portion of the Great Plains, is well delimited on the west by the Glorieta Mesa, the "Hills of Pedernal,"[34] and the Mesa Jumanes, which lie within the Basin-and-Range Province. The scarp used as the boundary line (altitude 6,250 to 6,500 feet) is fairly well shown on Hill's "Map of Texas and Parts of Adjoining Territories," accompanying his Physical Geography of the Texas Region.[35]

Southward from the Mesa Jumanes the topographic break which limits the Pecos Valley on the west is traced at the foot of the following mountain ranges in the order named: the Jicarilla, Capitan, and Sacramento ranges in New Mexico, and the Guadaloupe, Davis, Comanche, Caballos, and Santiago ranges in Texas. This carries the boundary to the Rio Grande at longitude 102° 30′ west. North of this river to the Southern Pacific Railroad (about forty miles), the boundary is fairly indicated by San Francisco Creek. The altitude of the foot of the Jicarilla Mountains at the northern end of this line is between 5,000 and 6,000 feet, but the altitude of the boundary declines somewhat uniformly to about 4,000 feet at the southern end. The exact plotting of this line awaits more detailed mapping. In any case the line is not a clear one for the mountains merge gradually into the plain, but there is no question concerning its rank as a major province boundary.

Middle Sections of the Great Plains.—The Great Plains Province embraces ten sections which must be distinguished in the description or explanation of the topography. These sections can best be distinguished and characterized by first considering the three which are represented in eastern Colorado and western Kansas. The middle one of these sections is well known as the High Plains. The other two are here called respectively the Plains Border and the Colorado Piedmont. The threefold division is well recognized both popularly and scientifically, but the names here used for the eastern and western strips are not in popular use.

The essential features of the topography of each of these sections and the nature of their boundaries will be best understood by reference to their origin. Consider these plains to have been a uniform smooth

[34] O. E. Meinzer: Water Supply Paper 275, *U. S. Geol. Surv.*

[35] Topographical Atlas, *U. S. Geol. Surv.*, Folio No. 3.

surface stretching from the mountains to eastern Nebraska and Kansas. The central strip or High Plains is what is left of this flat surface, still covered by the late Tertiary beds to which the flatness is due. The Plains Border is the strip on the east from which the Tertiary mantle has in large part been eroded and which is now dissected but not reduced to the low relief which characterizes the Central Lowland. It is in general a hilly country. The climate in this strip is slightly more humid than in the High Plains and the headwaters of east-flowing streams are pushing westward and broadening the Plains Border at the expense of the High Plains. The Colorado Piedmont has likewise lost much of its Tertiary cover and all of its original flatness, but for a different reason. Here the climate is drier than on the High Plains and the bunch grasses which grow here afford poor protection against erosion as compared with the closely matted sods of the High Plains.[36] These three subdivisions may therefore be regarded as (1) a strip of *residual plain* in the middle, (2) a strip of *degraded plains* on the west, and (3) a strip of *dissected plains* on the east.

The High Plains are limited on the north by the Pine Ridge escarpment, a north-facing scarp, locally 1,000 feet high, at the northern limit of the later Tertiary formations. It extends east from near the north end of the Laramie Mountains in Wyoming, thru the northwestern corner of Nebraska and northeastward into South Dakota about 50 miles south of the Black Hills. Farther east it loses its sharpness and near the 100th meridian it dies out.

The eastern and western boundaries of the High Plains cannot now be drawn with accuracy except for a part of the distance in their southern extensions. Here, in northwestern Texas and Oklahoma, the typical flat High Plains, under the name of Llano Estacado, are practically coextensive with the later Tertiary formations. In the states north of Oklahoma, these formations have been very much eroded and the original flat surface survives only in patches between streams. A good idea of their distribution is conveyed by the map given on the frontispiece in the paper by Johnson.[37] The topographic mapping of the Great Plains has not advanced sufficiently to make possible the accurate delineation of the area within which these remnants are abundant. For the present it is only possible to indicate the area still covered by the later Tertiary beds, as shown on the Geologic Map of North America. On the accompanying map this is done by a generalized line which excludes the marginal fringe. It is certain that the High Plains as here defined cannot exist outside of that area, but it is equally certain that much of the area thus included in the High Plains has not a representative topography. In other words, the rem-

[36] Willard D. Johnson: The High Plains and their Utilization, 21st *Ann. Rep. U. S. Geol. Surv.*, 1900, Part IV, p. 629.

[37] Willard D. Johnson: *loc cit.*, Pl. CXIII.

nants of typical High Plains exist only where the later Tertiary formations have suffered no erosion, while the boundary as shown in the accompanying map includes all the area from which these formations have not been totally removed. Two large areas which will need to be distinguished in a more detailed treatment of the area are the Sand Hill country of western Nebraska and Goshen Hole, an extensive denuded tract traversed by Platte River on the Wyoming-Nebraska boundary.

Northern Sections of the Great Plains.—North of the High Plains and separated from them by the north-facing Pine Ridge escarpment is the Missouri Plateau, so named because it is drained by the upper Missouri and its tributaries. Like the name "Allegheny Plateau," in the east, this name is applied to two sections, the one glaciated, the other not. The Missouri Plateau has a topography resulting from extensive degradation. Monadnocks or exhumed mountains show that this degradation has been, at places at least, several thousand feet. The Missouri Plateau, therefore, corresponds in a manner to both the Plains Border and the Colorado Piedmont, which here unite around the northern end of the High Plains. Erosion in a recent cycle has made extensive badlands which, in a more detailed classification, might be set off as a subsection.

Within the Missouri Plateau are several isolated groups of mountains of which the Black Hills constitute the largest. The size and physiographic importance of this domed mountain uplift require that it be treated as a separate section of the Great Plains Province. It is surrounded by residual monoclinal ridges, the outermost of which indicates the proper boundary of the section.

The Glaciated Great Plains, while mentioned here as a section, because of very limited extent in the United States, extend far to the north in Canada. Their extent is probably comparable with that of the unglaciated portion of the province. In the treatment of the entire area it will doubtless be found necessary to recognize more than one section in the glaciated portion, which may then, if desired, be treated as a subprovince.

Southern Sections of the Great Plains.—South of the Colorado Piedmont is the Raton section, a strongly characterized division in northeastern New Mexico and southern Colorado. It is characterized by high mesas (in part lava flows) cut by deep canyons; elsewhere by isolated buttes (chiefly volcanic) rising above the general level of the Plains. The southern edge of this subdivision is a south-facing escarpment overlooking the Canadian and Pecos Valleys.

For a distance of 400 miles in eastern New Mexico and western Texas the Pecos Valley borders the High Plains on the west. On the

east side rises the west-facing escarpment of the Llano Estacado (High Plains) 500 to 700 feet high. The Pecos Valley and the Raton section are genetically allied to the Colorado Piedmont; their forms (except volcanic) are due to erosion of the High Plains which formerly extended west to the Rocky Mountains.

South of the High Plains and continuous with them is the Edwards Plateau which, as a section of the Great Plains, includes the Stockton Plateau west of Pecos River. This section is distinguished from the typical High Plains on the north by the absence of a Tertiary cover (see Geologic Map of North America) and of the corresponding flat topography. In place of it is the more or less roughened surface of the strong and very thick Lower Cretaceous limestone. Pecos River crosses it in a narrow valley separating the Edwards Plateau, strictly so called, from the Stockton Plateau on the west. Except where the limestone substratum runs beneath the Tertiary cover on the north, the Edwards Plateau east of Pecos River is almost everywhere terminated by an escarpment. West of that river the plateau continues southward into Mexico and abuts against the mountains of the Basin-and-Range Province. The edges of the Edwards Plateau are dissecting. On its eastern and northern sides is a broad frayed margin analogous to the Plains Border farther north.

Texas Hill Section.—There is a large area in Central Texas which, for a want of a better name, may be called the Texas Hill section. The name is not satisfactory and its boundaries are not sharp; it is not itself a unit in topography, but comprises five or six subdivisions, each with its own individuality and needing separate treatment in any detailed account. The whole is, however, a dissected and partly-denuded tract, bordered on the one hand by residual plateaus and on the other by relatively low plains. It is more advanced in its erosion cycle than the plateaus on the west and south, and less advanced than the prairies on the north.

The topographic relation of this section to its neighbors is rendered clearer by a consideration of its origin. It should be remembered that the whole of central Texas was once covered by a great eastward-sloping cover of early Cretaceous strata, the Edwards limestone. This was underlain for the most part by weaker rocks, but not everywhere. West and south of the center, this strong cover still persists in the Llano Estacado and the Edwards Plateau. To the east in the Coastal Plain the same formation is buried, and the surface of the country is too near its baselevel to be deeply dissected. On the north, the same strong limestone has been entirely stripped away from the locally baseleveled Permian prairies. Only in the center is the work of reducing the strong rocks but half done. We have therefore on the west and

south, plateau *not yet* cut down; on the east, low plains *too low* to be much cut down; on the north, rolling prairie *already denuded;* in the center, a hill country *in process* of down cutting.

The above statement is necessarily the result of generalization. It is not to be expected that an area so defined should have clean-cut boundaries. However, the contrast between this area and its neighbors is sufficiently sharp to have received expression in the language of the people. From this source Hill has appropriated the names Burnet Country, Callahan Divide, Lampasas Country, and others which are applied to districts within this great area.[38]

The western and southern portions of this Hill section are merely the local representatives of the dissected *Plains Border* as defined above. The whole section is, in fact, a greatly expanded and diversified phase of the Plains Border. It is not a part of the "Great Plains," but it belongs in the Great Plains Province. As stated above, the strong limestone which makes the Edwards Plateau lies beneath the surface of the Coastal Plain, its dip being easterly. At the western margin of the Coastal Plain it emerges partly by reason of its easterly dip and partly because of the Balcones fault (p. 45). A considerably eroded north-south strip on the limestone west of this line is known as the Grand Prairie. With increasing altitude toward the west the limestone becomes deeply dissected. The rough country thus produced (north of Colorado River) is Hill's "Lampasas Cut Plain." Stretching westward from these "cut plains" to the still more rugged fringe of the Great Plains is a line of plateau remnants marking the "Callahan Divide" between the head waters of the Brazos on the north and those of the Colorado on the south. It is a rough country having the same history as the "cut plain" on the east and the "Plains Border" on the west, but in a more advanced stage of erosion than either of these. North of this line of buttes and mesas are the prairie benches and east-facing escarpments of the denuded Permian, drained by the Brazos head waters. To the south also, and hence within the section herein outlined, the headwaters of the Colorado have reduced many areas to lower elevation and gentler relief.

Much of this area, tho stripped of its former cover of Lower Cretaceous limestone, has not been reduced even approximately to its local baselevel because the rocks thus exposed are themselves resistant. This applies to the area of pre-Cambrian rocks in the southeast part of the province (Hill's "Burnet Country") and to a strip of Carboniferous rocks in the northeastern part of the section (Hill's "Palo Pinto Country"). These parts of the province are quite as rugged as the "Cut Plain" and the "Plains Border" with their partly-

[38] R. T. Hill: Topographical Atlas, *U. S. Geol. Surv.*, Folio No. 3, 1900.

destroyed cap of Edwards limestone, but the styles of relief are different.

On the south this section is not sharply separated from the Edwards Plateau. The latter is itself partly dissected, and progressively more so as its edges are approached. Hence on the north it passes gradually into the semi-denuded basin which is here styled the Texas Hill section. The line of separation here used is essentially the edge of the Lower Cretaceous as shown on the Geologic Map of North America. The area of pre-Cambrian rocks, and that in which Lower Cretaceous outliers are found, are assigned to the Texas Hill section.

On the west likewise, this section has been delimited from the Edwards Plateau and the Llano Estacado, largely on the basis of the geologic map. On the north, the topographic sheets of the United States Geological Survey have been used in separating this section of rough surface and outlying plateau remnants from the approximate peneplain of the Central Lowland.

Interior Highlands.

Ozark Plateaus.—The Ozark Province is distinguished from all its neighbors by its greater altitude. While the Ouachita Mountains are equally high, the part of that province which is adjacent to the Ozark Province, namely the Arkansas Valley, is a lowland.

Boundaries.—The most clearly marked boundary of the Ozark Province is on the southeast where it is separated from the Coastal Plain by a distinct topographic break extending from Cape Girardeau on the Mississippi southwest to the Arkansas River. Thru a part of this distance a scarp may be seen from the St. Louis, Iron Mountain and Southern Railway which follows the inner edge of the Coastal Plain generally five to fifteen miles from the boundary. The scarp marks the contact of Paleozoic rocks with Tertiary and Quarternary.

Northward from Cape Girardeau the Ozark Province is bounded on the east by the Till Plains. Their relatively low altitude and level surface clearly distinguish them from the more elevated and dissected Ozark Province. The characteristics of the latter are due to a dome-like uplift. The limits of this dome are not sharply marked, but the Mississippi flows approximately at its base and likewise marks the western limit of the glacial drift. It is therefore taken as the province boundary as far north as the mouth of Meramec River near St. Louis. In a similar manner the Missouri may be used as the northern boundary, but it is necessary to exclude from the Ozark Province the area of Carboniferous rocks lying west of the Mississippi and south of the Missouri near the mouth of the latter. This inter-stream area (St. Louis and vicinity) is a part of the Dissected Till Plains of the Central Lowlands.

Sharper topographic contrasts both on the north and on the east might perhaps be found by following certain geologic lines as is done elsewhere, but such lines would be more irregular than the rivers. A strip a few miles wide on the north side of Missouri River has a purely erosion topography no longer influenced by the wasted drift, altho the position of Missouri River was essentially determined by the edge of the drift. Such ragged edges are, however, the rule rather than the exception among physiographic divisions.

The western boundary of this province is least definite, but the contact between Lower and Upper Carboniferous rocks has already been used for a part of the distance.[39] Some of the distinctive Ozark features are associated with the Lower Carboniferous rocks and there is a similar association of the Upper Carboniferous with the prairies on the west and north; hence it seems best to use this contact as the province boundary as far as possible. Thru much of its extent it is followed by small streams which mark the boundary with sufficient accuracy for general purposes. In this way after leaving the Missouri River, Blackwater Creek might be followed and, after an interval, Osage River, Sac River and Cedar Creek in turn, and, still farther south, Spring and Neosho Rivers.

The southern boundary of the Ozark Province is at the southern base of the Boston Mountains. For most of the distance this is a ragged escarpment not many miles north or south of the parallel of 35° 30′. Locally the south-sloping dissected plateau called Boston Mountains, merges gradually into the Arkansas Valley. The line used in the accompanying map is a generalization from the topographic sheets of the United States Geological Survey.

Sections of the Ozark Province.—The Ozark Province consists of three rock terraces separated by the retreating escarpments of the higher terraces. The northern ones, embracing most of the province, are sufficiently alike to be included in a single section—the Springfield-Salem Plateaus— tho separated by the bold east-facing escarpment of the Mississippi limestone. The foot of the eroded north-facing escarpment of the Boston Mountains is indicated on the geological map of North America by the edge of the Upper Carboniferous in Northern Arkansas.

Ouachita Province.—The topography of the Ouachita Province is dependent on folded rocks—mildly folded in the northern section (Arkansas Valley), and closely folded in the southern section (Ouachita Mountains). On the east and south the topography thus determined is strongly contrasted with that on the flat-lying strata of the adjacent province. The boundary line on these sides is indicated on the geologic map by the edge of the Paleozoic rocks. On the west side

[39] Geo. I. Adams: *U. S. Geol. Surv.*, 22d Ann. Rep., Pt. II, p. 69.

the boundary is not accompanied by any geologic contrast. Even on this side the topographic break is in general well marked, tho for twenty or thirty miles south from Arkansas River the line is indefinite. It has been located by Taff[40] between the gently folded rocks and low level-crested ridges of the Arkansas Valley on the one hand and, on the other, the nearly horizontal beds which occasion the benches and low scarps of the Osage Plains.

The Arbuckle Mountains, west of the Ouachita, consist of deformed strata peneplained and uplifted or given local prominence by circumdenudation. Nowhere do they rise more than 400 feet above the adjacent prairies; the average for the area is much less. These so-called mountains are mentioned here because they have been treated by some as a part of the Ouachita Province. They are separated by ten or twelve miles of prairie plain whose character is more like that of the Osage Plains than like that of the Arkansas Valley. If the Lehigh Basin[41] between the two mountain ranges be classed with the Ouachita Province (Arkansas Valley), the Arbuckle Mountains become contiguous and should be included by drawing the boundary around them in such a manner as to include all strata older than Devonian.[42] In the accompanying map and classification the Arbuckle Mountains, like the much higher Wichita farther west, are regarded merely as an exceptional feature of the Central Lowland.

The boundary between the Ouachita Mountain section and the Arkansas Valley section is fairly indicated by the Rock Island and Pacific Railway which in general follows the first valley north of the mountain section. It runs a little north of the 35th parallel in Arkansas and a little south of it in Oklahoma. A few miles east of McAlester, Oklahoma, this line intersects the western boundary of the province.

Rocky Mountain System.

Southern Rocky Mountains.—Between central Wyoming and northern New Mexico the southern Rocky Mountains form a continuous mountain area, interrupted only by such valleys as belong distinctively to a mountain country.

Except near the south end, the entire eastern boundary of this mountain province is easily traced on the contour map of the United States (scale 40 miles to 1 inch) and may be seen as a mountain front by an observer standing a few miles distant on the Great Plains. In southern Colorado and northern New Mexico, such observations are less satisfactory. This portion of the Great Plains Province is itself very rugged, a high and deeply dissected plateau belonging to the

[40] Joseph A. Taff: Tishomingo folio No. 98, *Atlas U. S. Geol. Surv.*, 1903, p. 1.

[41] See Coalgate folio No. 74, *U. S. Geol. Surv.*, and Atoka folio No. 79, *U. S. Geol. Surv.*

[42] Joseph A. Taff: *U. S. Geol. Surv.*, Prof. Paper, No. 31, p. 13.

Raton section. Views of the mountain front must therefore be had from high points on the plateau.

The eastern boundary of the province is likewise clearly marked on the geologic map. In general the Cretaceous and all younger rocks belong to the Plains Province, the exceptions being only a narrow belt of hogback foothills. The very narrow zone of Jura-Trias, where present, belongs to the same foothill belt and therefore to the mountain belt, which likewise includes all older rocks. The ranges thus fronting on the Great Plains are the Laramie, chiefly in Wyoming; the Colorado Front Range from near the Wyoming boundary to the Arkansas River; the Wet Mountains (*en echelon* with the Front Range) from the Arkansas to Huerfano Park; and the Sangre de Christo Range (*en echelon* with the Wet Mountains) from Huerfano Park to the southern extremity of the province.

The southern limit of the Sangre de Christo Range is definite, both structurally and topographically. This granite-cored mountain uplift comes to an end at the Glorieta Mesa. The boundary here is essentially at the Santa Fe Railroad. There are other mountains in line with the Rockies farther south, but they are of different type, allied with those of the Great Basin and the Mexican Highland.

For some distance west and north of Santa Fe it is impossible to draw a province boundary which shall include all the related mountains without at the same time including considerable areas of plateau continuous with the Colorado Plateaus Province. The Rio Grande Valley west and north of Santa Fe is ten to twenty miles wide, its floor being a dissected plateau. This is continuous at the north with the broad flat plateau (Mesa de los Viejos) in which the Rio Chama has cut its canyon. West of the south end of the Sangre de Christo Range and separated from it by the valley of the Rio Grande are the Jemez Mountains and, on their western edge, the Nacimiento. The Jemez Mountains consist largely of dissected lava flows and tuffs and are thus similar to the San Juan Mountains to the north, the volcanic cover being continuous between them. The Nacimiento Range is a linear uplift similar to the Sangre de Christo. The character of both would justify their inclusion in the Rocky Mountain Province. It seems on the whole most consistent to include them, altho this necessitates including also parts of the broad Rio Grande Valley and the Mesa de los Viejos which separate the Jemez Mountains from the Sangre de Christo. The line here is much generalized, including in the mountain province the entire lava-covered belt of which the Jemez Mountains are the southern end and, in addition, the Nacimiento. A number of isolated eminences west of the lava-covered belt[43] are

[43] See Topographic Map of the United States, *U. S. Geol. Surv.*, 1913; also Topographic Sheet, Gallina Quadrangle.

apparently mere residual buttes incident to the large amount of erosion which has occurred on the Colorado Plateau.

North of the Rio Chama the province boundary soon becomes clear. For a long distance it is marked by the Dakota (Cretaceous) hogback which follows closely the edge of the volcanic rocks of the San Juan Mountains.

In southwestern Colorado the mountain province comprises, in the main, all rocks older than Mesozoic, together with contiguous areas of eruptives. A boundary line so located will include in the mountain province south of latitude 38° 45′ the following contiguous ranges and groups: San Juan, La Plata, Rico, Uncompahgre, and West Elk. Certain parts of this line are highly irregular by reason of spurs and embayments in the mountain front. Moreover, the agreement of this front with the actual contact of the rocks mentioned is necessarily only approximate because of erosion and minor structural features, such as hogback foothills. The two lines, topographic and geologic, are, however, fundamentally related. The final appeal is, of course, to the topography, the geology being understood to be interpretative rather than definitive. Further refinement in the location of this boundary awaits more detailed work.

North of latitude 38° 45′ it is necessary to include in the mountain province all the closely-grouped laccolitic mountains which lie in the reëntrant between the Elk Mountains and the West Elk. The boundary may be considered to run tangent to their bases and to continue north along the line of the Huntsman's Hills, a prominent range of monoclinal foothills on the west side of the Elk Mountains. With a break of only a few miles at the valley of Grand River, this strong monoclinal ridge is continuous to the northwest all the way to the Uinta Mountains. It ranges in height from 500 to 1,500 feet. North of Grand River it is called the Grand Hogback. Here it flanks the White River Plateau, a mountain structure of the Uinta type (see below). Thruout its length the west or southwest slope of this great monoclinal range merges into the Colorado Plateau. Its east or northeast slope facing the mountain province is generally scarp-like.

The White River Plateau is a true mountain uplift,[44] tho like the Uinta Range its uplift was accomplished without greatly disturbing the horizontality of the strata except on the flanks where they are steeply upturned. Its summit, known locally as the Flattop Mountains (formed in part of lava flows), rises to levels of 10,000 to 12,000 feet.

The boundary of the Southern Rocky Mountain Province on the north and east sides of the White River Plateau is similar to that already described on the southwest side, but the ridges are less con-

[44] C. A. White: *U. S. Geol. Surv.*, 9th Ann. Rep., p. 705.

tinuous and imposing. A southeasterly extension of the Wyoming Basin east of the White River Plateau reaches south to Grand River. North of that river the Park Range (here the westernmost range of the Southern Rocky Mountain Province) is separated from the Wyoming Basin by a fairly abrupt topographic break. The province boundary is marked by hogback foothills.

In assigning the above described limits to the Southern Rocky Mountain Province, a considerable area of lofty and deeply dissected plateau of nearly-horizontal strata is also included between the White River Plateau on the northwest and the Elk, Holy Cross and Park Ranges on the south and east. The highest plateau remnants in this district are more than 11,000 feet above the sea. The general aspect of this country is mountainous and its relations to the structurally deformed areas are intricate. In so far as it cannot be called true mountain it is properly treated as an intermontane feature of the mountain province.

The Southern Rocky Mountain Province terminates at the north in three branches or prongs which indent the Wyoming Basin. These are the Sierra Madre or Encampment Mountains (the northern extension of the Park Range), the Medicine Bow Range, and the Laramie Range. All these rise somewhat abruptly above the plains of the Wyoming Basin. The edge of the mountain province is at most places marked by hogback foothills. Except for a local and narrow belt of Mesozoic foothills, all rocks of that age and younger are excluded from the mountain province.

Wyoming Basin.—The two mountain provinces, northern and southern Rockies, are not connected by any continuous range. On the other hand, a plateau surface is continuous from the Great Plains on the east to the Colorado Plateau on the south. South and west from central Wyoming, this transverse plateau expands into a basin having an extreme east-west length of 250 miles and an almost equal width. Single ranges from the mountain provinces project finger-like into this basin, and some low isolated mountains rise from its plateau surface. These would be higher if not buried in part by younger horizontal beds. They indicate that structurally the two mountain provinces are continuous.

The small isolated ranges in the Wyoming Basin are mainly in the northeastern part. Their structural trend is more nearly east-west than north-south and is therefore in line with that of the adjacent ranges of the two mountain provinces, the Wind River, Owl Creek, and Bridger Ranges on the north, and the north end of the Laramie Range on the east. This serves to emphasize the unity of the whole Rocky Mountain system. Topographically, or geographically, it is

interrupted, but geologically it is continuous beneath the horizontal sediments which make the Wyoming Basin.

The boundaries between this basin and the Southern Mountain Province have already been traced (p. 79). The boundary between this province and the Northern Rocky Mountains is described under the head of the latter (p. 81). Both are topographically clear and both lie near the line of contact between the Mesozoic (or younger) rocks and the Paleozoic (or older). For a large part of the distance the boundary is marked by hogback foothills.

For a stretch of fifty miles at the northeast there is no prominent barrier between this basin and the Great Plains. They must be separated by a more or less arbitrary line connecting the Bighorn Mountains with the Laramie Hills. By following anticlinal axes more or less marked by lines of hills, the gap to be crossed may be reduced to about fifteen miles. The boundary thus located runs from a point on North Platte River six miles west of Caspar, in a north-northwesterly direction, allotting to the Wyoming Basin all rocks older than the Niobrara Cretaceous.[45]

The continuity of the Wyoming Basin with the Colorado Plateau on the south is less perfect than with the Great Plains on the east. Between the basin and the Colorado Plateau lies the range of Danforth Hills, a broad, complex, and deeply eroded, anticlinal ridge 1,000 to 1,500 feet in height. This ridge connects the Uinta Range of the Northern Rocky Mountain Province with the White River Plateau of the Southern Rocky Mountain Province. The Danforth Hills are plateau-like rather than mountain-like, and are, therefore, included in the Wyoming Basin. Isolated uplifts of similar structure and topography are found within the basin. White River flows at the southern base of the Danforth Hills and approximately marks the province boundary.

Northern Rocky Mountains.—The Northern Rocky Mountain Province embraces all contiguous mountains in the United States north and west of central Wyoming to the Cascade Mountains in northern Washington. For about seventy-five miles south of the International Boundary the Rocky Mountain system borders on the Cascade range. Thruout its remaining 2,500 miles, the boundary of this province is marked almost everywhere by a contrast of mountains on the one side and plateau on the other. For the greater part of this distance the contrast is sufficiently sharp to be visible in the field within a single view. The boundary line traced in this way is highly irregular. The province is not of compact shape, but shows irregular projections. The advantage of drawing the boundary in this detailed way

[45] Manuscript map by C. J. Hares; prepared for *U. S. Geol. Surv. Bull.*, No. 641.

is that the line on the map corresponds to something visible in the field. The area within the line is all mountainous, the valleys being so narrow as to be plainly incidental to the mountain character. Greater compactness might be given to the province by generalizing the boundary line, but such compactness would exist only on the map and not in nature.

The province as thus outlined embraces several scores of separate ranges and many important valleys bearing distinct names. The ranges differ in topography, structure, and physiographic history, but all together form a continuous expanse of mountain country extending northward far into Canada.

The boundary between this province and the Great Plains on the east has already been traced in discussing the latter. At the south end of the Bighorn Mountains, where that range curves to the west under the name of Bridger and Owl Creek Mountains, the province boundary nowhere departs very far from the contact of the Cretaceous and Tertiary rocks on the one hand and the older rocks on the other. By following this contact the boundary may be traced with considerable accuracy on the Geologic Map of North America. Locally the boundary is marked by hogback foothills. The valley of Wind River is thus included in the Wyoming Basin. The Wind River Mountains form a long peninsula of the mountain province indenting the Wyoming Basin. Around these, as elsewhere, the boundary line follows hogback ridges where present, and essentially the edge of the Tertiary rocks where such ridges are absent. In like manner the line surrounds the upper Green River Basin, following the southern foothills of the Gros Ventre Range and the eastern foothills of the Hoback and Wyoming Ranges. South of latitude 42°, the ranges of western Wyoming decline in altitude and become mere parallel lines of hogbacks, rising to a maximum height of 700 feet above the plains which here occupy much more of the area than do the mountains. It seems best, however, to treat this shrunken extension of the large mountain ranges as a part of the mountain province. The boundary line is accordingly extended south at the foot of the easternmost monoclinal ridge of Mesozoic strata.

Near the southwestern corner of Wyoming the line passes to the northern foot of the Uinta Mountains. By the criteria named above, it surrounds this range which overlooks the Wyoming Basin to the north and the Colorado Plateaus to the south. Continuing southward to Mount Nebo, at the southern extremity of the Wasatch Range, the line follows the base of the mountains to Salt Creek and Nephi. All rocks older than Mesozoic are plainly in the mountain province.

Going north at the west foot of the Wasatch, the province boundary is marked by a perfectly clear and abrupt topographic break separating

the Wasatch Mountains from the Great Basin. This boundary is so located as to leave to the west all the Quaternary filled basins, so highly characteristic of the Great Basin. It follows the valley of Bear River northward to latitude 42° 40′. Thence it continues north along the course of Blackfoot River at the western base of the Blackfoot Mountains.

At a point south of Idaho Falls the line thus described intersects the boundary of the Snake River Plains. Northeast of that point to latitude 44° 30′ the boundary of the mountain province lies close to Snake River and its tributary, Henry's Fork. West and southwest of Yellowstone Park the province boundary separates two lava plateaus, the lower, nearly level and unforested Snake River Plateau on the west, and the higher, forested and rougher plateau of the Yellowstone on the east. The Snake River Plateau consists essentially of basalt; the Yellowstone Plateau, of rhyolite. Disregarding a moderate amount of recent erosion, the relatively level basalt surface may be seen to abut against the edge of the rhyolite. The difference in altitude between the two plateaus ranges from several hundred to several thousand feet.[46]

In latitude 44° 30′ the province boundary turns west at the southern foot of the east-west mountain range which here forms the continental divide. The basalt continues on the lower or plains side of the line, while the rhyolite on the north soon gives way to the strong metamorphic rocks of the mountains of southeastern Idaho and later to the granitic rocks of the great Idaho batholith. In a large way the geologic line thus defined is in striking agreement with the foot of the mountains and the edge of the plateau. The altitude of this line is about 6,000 feet in eastern Idaho, but declines westward. The boundary line thus defined continues west to longitude 116° near Boise City, thence nearly north at the contact of the lava flows on the west with the ancient batholith which constitutes the Salmon River Mountains.

Between the parallels of 45° and 45° 30′ there lies, west of the great compact mass of mountains, a semi-detached mass called the Seven Devils. This corresponds in a general way to the area shown as Jura-Trias on the Geological Map of North America. These mountains are separated from the great mountain mass to the east by narrow valleys only and not by a portion of the plateau. They are therefore included in the Northern Rocky Mountain Province. The profound canyon of Snake River borders its western base and is taken as the province boundary at this place. West of the canyon is a narrow strip of the lava plateau, beyond which rise the Blue Mountains, a section of the Columbia Plateau Province.

North of the Seven Devils, the province boundary returns to the

[46] Compare Transcontinental Guidebook, *U. S. Geol. Surv.*, Bull. 611, 1915, Pl. 15C and 15D.

contact between the Columbia basalts and the crystalline rocks of the great batholith (Clearwater Mountains). The western front of the mountains is bold tho irregular, being indented by lava-filled bays. North of the great batholith, the metamorphic sediments which constitute the Coeur d'Alene Mountains present a similar front to the west, being everywhere limited by the edge of the basalts. The granite hills west of Coeur d'Alene Lake rise above the lava plateau and are included in the mountain province. East of Spokane is a reëntrant in the outline of the mountain province, indicated on the Geologic Map by an eastward extension of the recent lavas. Westward from this locality to the Cascade Mountains the province boundary is well marked by the Spokane and Columbia Rivers.[47] Only a small patch of the lava plateau occurs north of the Columbia, east of the mouth of the Okanogan.[48]

Okanogan River is customarily spoken of as the boundary between the Northern Rocky Mountain Province and the Cascade Mountains. Properly speaking, the entire Okanogan Valley, twelve miles in width, should be included in the former province which is, in this part, much lower than the Cascade Mountains. The steep east front of the latter lies about ten miles west of the Okanogan at the International Boundary.[49] At this place Similkameen River marks the boundary sharply. The boundary here used continues the line of Similkameen River southward at an elevation of about 3,000 feet.

Intermontane Plateaus.

Columbia Plateau.—Included between the Northern Rocky Mountains, the Cascade Range and the Basin-and-Range Province, is the Columbia Plateau, so named because it lies mainly within the drain-

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[47] When the Rocky Mountain provinces are divided into sections the relatively low rounded mountains west of Colville and Columbia rivers (longitude about 117° 30′) must be distinguished from the higher and more rugged mountains to the east. For some purposes, geologic rather than physiographic, it is convenient to consider this section as a member of the Intermontane Plateaus which thus become a continuous belt from Mexico to Alaska. Topographically, this great longitudinal belt is interrupted by a narrow transverse belt of low mountains. This mountain section is totally unlike the plateau to the south but it grades into the Interior Plateau of British Columbia which, like much of the Intermontane Plateau belt in Canada and Alaska, consists of worn down mountains with local remnants of horizontal lava flows. In treating the entire continent the northern and southern halves of the Intermontane Plateau belt should be made divisions of coördinate rank. For purely physiographic and geographic studies, these are separated by the narrow transverse belt of mountains in northern Washington. In studies of another character these low mountains may be included in the northern division.

[48] J. T. Pardee: Personal communication.

[49] For description of local topography see G. O. Smith and F. C. Calkins: A Geological Reconnaissance Across the Cascade Mountains along the 49th Parallel, *U. S. Geol. Surv. Bull.*, No. 235, p. 13.

age basin of Columbia River. As a plateau of horizontal rocks (with only local exceptions and these not on the border) it is necessarily contrasted with the adjacent mountains. The boundary on the north and east has already been described in connection with the Rocky Mountains.

The province boundary on the west is the foot of the Cascade Mountains. Both structurally and topographically the eastern border of this range in Washington is irregular and the boundary here given is at best an approximation. In Oregon the mountain front follows a more regular line along the west side of the Deschutes Valley.

The southern boundary of the Columbia Plateau is against the Great Basin.[50] The choosing of a boundary on this side is difficult. The characteristics of the two provinces are nevertheless so different that they must be separated by some line however arbitrary. The distinguishing characteristic of the Columbia Plateau is its plateau surface on a substratum of lava. Those of the Great Basin are isolated mountain ranges separated by plains on unconsolidated detritus. In general the drainage of the Great Basin does not reach the sea, but distinctions in drainage (interior and exterior) cannot be used to define provinces (see p. 90). On the accompanying map a line has been drawn which, so far as possible, touches the northern ends of the northernmost Basin Ranges, leaving as little as possible of the lava plateau south of the line. From the Geologic Map of North America it appears that a considerable lava-covered area, probably in large part plateau and not covered by Quaternary sediment, is thus assigned to the Great Basin in Oregon, Nevada and California. However, at least a part of this is known to be characterized by tilted fault blocks, one of the types of basin ranges.

It also appears that a considerable area in central Oregon, here assigned to the Columbia Plateau (Harney section), is covered by Quaternary sediments which are typical of the desert basin to the south. The extent and thickness of such a covering in this little studied country are uncertain. The subaerial accumulation is certainly insufficient to prevent typical plateau dissection of the basalt substratum in the basin of Crooked River, the largest eastern tributary of the Deschutes.

The boundary line in southeastern Idaho runs parallel to Snake River and not far from it. As here drawn it follows essentially the northern edge of the Quaternary deposits as shown on the Geologic Map of North America. This is not the limit of the Snake River drainage basin, which extends far to the south between the several mountain ranges. Passing southwest into Nevada, the edge of the basalt plateau becomes essentially the divide which limits the Snake River Basin.

[50] For the use of this term see p. 89.

In northern Nevada this divide turns to the northwest and continues to form the province boundary to the 43d parallel—that is to the north end of Steen's Mountain. This north-south ridge and many west of it in southern Oregon have been described by Russell[51] as tilted fault blocks and have been used by Davis as his type of young block mountains. Their relations are plainly with the Basin-and-Range Province. The boundary on the accompanying map is drawn in a rough way tangent to their northern ends. The basin of interior drainage centering in Malheur and Harney Lakes is thus assigned to the Columbia Plateau.

The subdivisions of the Columbia Plateau are as yet imperfectly outlined for want of detailed investigations. Little can be said of their limits except what is contained in their definitions given on page 41.

Colorado Plateaus.—*Boundaries.*—The Colorado Plateaus Province occupies the greater part of the basin of Colorado River from which it takes its name. Its characteristic topography is determined in the main by greatly elevated, nearly-horizontal, strong strata, locally covered by lava flows. As thus characterized, the province is distinguished from its neighbors on all sides except from the Wyoming Basin. The mountains on the north and east are not only higher but have different topography and structure. In the Nevada Basin on the west and the Mexican Highlands on the south and southeast, horizontal beds are in general limited to the Quaternary filling of local basins. These beds are not indurated and not relatively elevated and are not, in general, subject at present to plateau dissection. They are therefore clearly distinguished topographically from the Colorado Plateaus.

The features here named as characteristic of the Colorado Plateaus fail, however, to distinguish them from the Wyoming Basin. The border-land between these provinces is described on page 80. In the accompanying map the boundary follows White River which flows at the south foot of the Danforth Hills, a complex anticlinal ridge which forms a structural connection between the Uinta Range and the Southern Rocky Mountain Province. Topographically the ridge is not of sufficient importance to require that it be included in the Rocky Mountains. It rises only 1,000 to 1,500 feet above the plateau level, but its location and its structural relations give it importance as a connecting link and a boundary line.

The least satisfactory boundary of the Colorado Plateaus is in New Mexico. That portion which concerns the Southern Rocky Mountain Province between the San Juan and the Nacimiento Ranges has already been discussed. South of these mountains the boundary line separates

[51] I. C. Russell: *U. S. Geol. Surv.*, 4th Ann. Rept.

the Colorado Plateaus on the west from a northern arm of the Mexican Highland on the east. As a part of the Basin-and-Range Province the latter includes débris-filled basins among its characteristic features. The valley of the Rio Grande in this part of New Mexico is typical of such basins except that it is now traversed by a thru-flowing stream. Its western boundary is against a typical portion of the Colorado Plateaus. This determines the province boundary about as far south as latitude 34° 30′.

Leaving the Rio Grande Valley and turning southwestward in latitude 34° 30′, the boundary becomes indefinite, partly for want of sharp distinctions in Nature and partly, perhaps, because of the lack of detailed surveys of the region. As drawn on the accompanying map the line passes west of the Sierra Ladron; thence westward on the south side of the Bear, Gallina, and Datil Mountains. Those mountains appear to be remnants of nearly horizontal strata[52] rising several thousand feet above the adjacent plains. They are therefore features of the Colorado Plateaus rather than of the Basin-and-Range Province, whose mountains are generally north-south ranges due to deformation. The line so drawn leaves to the south the Plains of San Augustin. This is a typical bolson. The Quaternary deposit which makes its floor is at least several hundred feet deep and may be much deeper. East of it is a small bolson of the same character. The nature of the mountains south of these plains is not known. Whether these bolsons occupy structural basins as do the characteristic bolsons of the Basin-and-Range Province is not known. Other origins are possible, but in the absence of more definite knowledge these bolsons are classed in the province of which the type is characteristic. Along the west side of this basin the line trends directly southwestward to the Arizona boundary, following the straight line of San Francisco River and its headwaters, the Tularosa, excluding from the plateau the Mogollon[53] and Tularosa Ranges.

At the Arizona state line, latitude about 33° 30′, the province boundary turns abruptly to the northwest. It crosses the Clifton quadrangle (see U. S. Geol. Surv. topographic sheet), leaving all good plateau remnants to the north. Thence northwestward to Fort Apache (longitude 110° W.), the line follows essentially the divide between the Gila River and the Little Colorado. On the north side of this divide the headwaters of the Little Colorado have incised themselves but little and the plateau is in large part preserved. On the other hand the tributaries of the Gila have steep gradients and among them the plateau is in large part destroyed. Continuing westward along the same divide, the line follows the edge of the lava-covered Mogollon Mesa.

[52] D. E. Winchester: Personal communication.

[53] Not to be confused with the Mogollon Mesa of Arizona.

Along the entire edge of this mesa, the boundary of the plateau is essentially at the edge of the lava. For a long distance south and west of Flagstaff, Verde River occupies a valley at the foot of the escarpment. The latter at this place is known as the " Verde Breaks."

It will be observed that from the valley of the Rio Grande westward to Mogollon Mesa the boundary of the province follows no geologic line shown on available maps. Along the edge of that mesa the boundary follows the contact of lavas on the north with the lower-lying Carboniferous on the south. West of the headwaters of the Verde the plateau edge for a long distance agrees with the edge of the Carboniferous rocks and the line may be traced from the geologic map. South of the Santa Fe Railroad there lies at the edge of the plateau a lower bench whose edge is called the Juniper Mountains.[54] This lower bench has a typical plateau surface on horizontal Carboniferous rocks. Farther to the northwest is another bench, the Truxton Plateau,[55] whose surface consists of crystalline rocks, locally plateau-like, but grading into mountain forms which are typical of the Basin-and-Range Province. Back of these (on the northeast side) the edge of the Carboniferous rocks forms the Yampai Cliffs. These mark the province boundary and are continuous with the west-facing Grand Wash Cliffs which cross the Colorado at the mouth of the Grand Canyon near the 114th meridian.

The Grand Wash (fault) Cliffs continue north of the Colorado to the Virgin River in southwestern Utah, which the province boundary follows for a few miles, thus passing to the Hurricane fault scarp which continues in the same direction (north-northeast) through Cedar Lake (Rush Lake) and Parowan Valleys at least to Beaver.[56] Thence the province boundary continues in the same general direction at the west foot of the Tushar and Pavant Ranges. These, as stated by Dutton,[57] are of intermediate character between the High Plateaus and the Basin Ranges. They are, however, considered to be more closely allied with the former. Moreover, the Quaternary valley filling, so highly characteristic of the Nevada Basin, begins at their western foot. The same line continues north at the west foot of the Gunnison Plateau to Mt. Nebo, the southern extremity of the Wasatch Mountains. Thence around the Wasatch and Uinta Ranges the line has already been described.

Within the great area thus surrounded are many plateaus needing individual description, separated by fault scarps, erosion scarps, and

[54] N. H. Darton: *U. S. Geol. Surv.*, Bull. 435, Map, Pl. I.

[55] Willis T. Lee: *U. S. Geol. Surv.*, Bull. 352, Map, Pl. I.

[56] Dutton: Atlas of the High Plateaus of Utah, *U. S. Geol. and Geogr. Surv. Rocky Mtn. Region*, Sheets 2, 4, and 8, 1879.

[57] Geology of the High Plateaus of Utah, p. 7.

deep canyons. They differ in elevation, degree of dissection, and climate. There are also volcanic mountains and local orogenic uplifts interrupting the general plateau character; but as a distinct physical division of the United States this province has, amid great variety, certain fairly constant characteristics which consistently distinguish it from its neighbors.

Sections of the Colorado Plateaus.—While the subdivision of this province into sections is still somewhat tentative, certain parts of it may be pointed out as possessing distinctive characteristics. These demand separate consideration in any detailed treatment of the province. The High Plateaus of Utah are a strongly individualized district. With them should be included, for purposes of rational treatment, the gigantic rock terraces at their southern end. Another well-marked section is the broad, deeply eroded rock terrace lying south of the Uinta Mountains, known in part as the Uinta Basin, and terminated by the great south-facing escarpment which bears in succession the names West Tavaputs Plateau, East Tavaputs Plateau, Roan Cliffs, Book Cliffs, and Grand Mesa. (The Roan Cliffs and Book Cliffs are locally distinct and parallel escarpments). The series of fault block plateaus north of the Grand Canyon, sometimes collectively known as the Kaibab section, may be combined with the San Francisco Plateau south of the Colorado and Little Colorado. The Grand Canyon section thus formed is well distinguished from its neighbors except on the southeast. Here it may also be bounded with a fair degree of definiteness if a southeastern section be recognized as characterized by volcanic features, and for the most part by an igneous cover. This is the Datil section. The Navajo country in northeastern Arizona and the San Juan Basin in northwestern New Mexico together comprise a vast area of terraced plateaus, characterized by retreating rock scarps. The "Canyon Lands," located mainly in southeastern Utah, differ so strongly from other sections of the province that a superficial observer would see little reason for including them in the same province. To the south these pass by degrees into the scarped plateaus of the Navajo section. To the east they merge into the type of country which prevails at the west foot of the Rocky Mountains, best known by its farm lands in the Grand, Gunnison, and Uncompahgre Valleys.

Basin-and-Range Province.—*General Relations.*—West and south of the Colorado Plateaus is a vast area marked by certain dominant characteristics from southern Oregon to the interior of Mexico. This great region is, for the most part, a highland, but even where low, as in southeastern California and southwestern Arizona, the most characteristic features are the same in kind tho differing in their development.

No single name is in general use to designate this entire area. Its northern half (including two sections) is roughly coextensive with the Great Basin. Its southwestern part is the northern continuation of the Sonoran district of Mexico. The southeastern part is the northern continuation of the Mexican Highland. Because of the continuity of essential features thruout the entire region, it is desirable to treat this large region as a single province and to designate it by a single name, the more so because its subdivisions cannot be sharply delimited. The fitness of the term *Basin-and-Range* Province will appear from the characteristics named below.

The distinctive features of this great area are isolated, nearly parallel mountain ranges (presumably fault blocks) and intervening plains made in the main by subaerial deposits of waste from the mountains. These deposits are locally very deep and generally unconsolidated. The consolidated older strata and lavas which make the mountains are only locally horizontal. In general they are deformed, and locally very much so.

With respect to the above-mentioned structural features, and the topographical features resulting from them, this great region is clearly contrasted with the Colorado Plateaus. It is less sharply contrasted with the mountains on its border, notably the Wasatch and Sierra Nevada. The greater size of these ranges makes them exceptional and their contiguity with other ranges justifies their assignment to the mountain provinces. The Basin Ranges, on the other hand, are smaller and isolated. Aside from these things there is great similarity between the mountains within the Great Basin and those on its border.

From the close geographic relations between the Great Basin and the kind of mountains here mentioned, the latter have come to be called Basin Ranges. The larger area characterized by them was therefore called by Powell the Basin Range Province. By this name the impression seems to be conveyed that the region is primarily one of mountains, whereas the area of intervening, nearly-flat basins is in reality much greater. In a large view the local desert basins and the mountain ranges are of coordinate importance in the character of the country; hence the change of name to *Basin-and-Range.*

Great Basin Sections.—As already stated, the northern part of this region is roughly coextensive with the area of internal drainage which John C. Fremont named the Great Basin. Its strongly-marked and very characteristic structural and topographic features are, however, not quite coextensive with the basin of internal drainage. In geologic and geographic writings the name Great Basin has generally been used with primary reference to these characteristic surface features and without regard to the actual limits of drainage basins. Probably this custom is firmly fixed and will continue. The area so described

embraces two sections—the Oregon Lake section and the Nevada Basin. There is frequent occasion to speak of these together and in doing so the name Great Basin will be used.

The boundaries of the Great Basin will depend on which one of its characteristics is regarded as most significant and is therefore made the criterion for its delimitation. A little reflection will serve to show that the difference between internal and external drainage cannot be used as a criterion for the purpose here in hand. It would, in the first place, require that the western boundary be drawn at the crest of the Sierra Nevada and Cascade Mountains instead of at the foot, whereas it is evident that the eastern slope of that range is just as much a part of the mountain province as the western slope. The physiographic history, features, and classification of the eastern slope of the Sierras are in no way dependent upon what becomes of the water twenty miles farther east. In a similar way some stream valleys leading outward from the Great Basin may contain thru-flowing streams or may, in wet seasons, deliver water to permanent streams in other provinces. Thus the thru-flowing Pitt River, a branch of the Sacramento, rises in northeastern California where it and its tributaries (many intermittent) drain a large area which is generally spoken of as a part of the Great Basin. Other streams of the same character flow thru the same kind of country in other directions and do not reach the sea. So far as physiographic character and classification are concerned, the upper basins of such streams cannot be grouped according to the destination of their waters. It is doubtful whether divides and stream courses ever make significant physiographic boundaries except where the location of the divide or stream is merely incidental to some more significant fact, generally one of structure.

The most central and significant feature of the Great Basin seems to be the accumulated waste from its higher parts, building plains in its lower parts. This is related on the one hand to the structure of the province and on the other to its climate. Along streams entering the basin from other provinces, such deposits do not begin until the proper limits of this province are reached. Again, where such deposits are found along stream courses leading outward from this province to thru-flowing streams, their presence indicates ineffective drainage in that portion of the stream basin where they are found. This inability of the running waters to forward the waste derived from higher slopes is a much more important fact in the character of the country than the mere fact that the water is, at some remote point, evaporated or that it ultimately reaches the sea. In addition to the above-mentioned considerations, these surficial deposits are very important in the classification of soils, and it is desirable so far as possible that the

conventional boundaries of physiographic provinces should agree with those of soil provinces.

For the practical delimitation of the Great Basin it seems best to assign coordinate importance to the characteristic mountains and to the detrital covering of the basin floors. The two are not quite coextensive, especially on the northern side. Internal drainage is disregarded. It is a characteristic but not a criterion.

The eastern boundary of the Great Basin, against the Rocky Mountains and the Colorado Plateau, has already been traced. Immediately to the west of the boundary already described, Quaternary sediments begin to form the floors of basins between elevations which are for the most part (presumably) block mountains.

The western boundary of the basin is at the foot of the Sierra Nevada and Cascade Mountains. The foot of these mountain ranges, while locally difficult to determine within a few miles, is generally a more consistent line than could be found by following the edge of the Quaternary deposits. These boundaries can best be described under the head of the mountain province.

In common usage the application of the name Great Basin in southern California is very indefinite. Powell, in his sketch of physiographic provinces (1896), limited it only by the Pacific Ocean and Colorado River, allowing it an indefinite extension into lower California. Elsewhere the name is limited to its strict hydrographic sense. A much more significant fact in physiographic description is this: North of latitude 35° 30′ the space occupied by the block mountains is more than half the total area; south of that line it is not more than one-sixth of the total.[58] North of that line the mountains are not only longer and broader but higher and composed of younger rocks. The mountains appear to be less advanced in the erosion cycle. These contrasted types of country are fairly well separated by an east-west line in latitude 35° 30′. South of that line and west of Colorado River is the Sonoran Desert. The remaining portion of the southern boundary of the Great Basin is formed by Colorado River. The separation at this line from the Mexican Highland is purely arbitrary; that is, it is not based on physiographic contrasts. The chief reason for making the division is convenience in geographic treatment. In referring any locality to one section or the other, it should be remembered that the distinction is merely geographic, not physiographic.

As stated above the Great Basin embraces two of the six sections of the Basin-and-Range Province. Most of it lies in the Nevada Basin whose characteristics have already been mentioned as typical of the Great Basin. That part of the Great Basin which lies in southern

[58] Compare the Geologic Map of North America, *U. S. Geol. Surv.*, 1911; also, Isaiah Bowman: Forest Physiography, Pl. IV and p. 222.

Oregon, with a strip of indefinite width in northwestern Nevada and northeastern California, is distinguished as the Oregon Lake district. It is an area of young block mountains of simple monoclinal structure, composed of recent volcanic rocks. Correlative with these block mountains are intervening troughs with many lake basins. The sediments accumulating in these structural troughs are not yet deep. Further investigations may lead to further subdivisions of the Great Basin. Geographically the drainage basin of former Lake Bonneville may be distinguished from that of former Lake Lahonton, but it does not appear that their difference in character is sufficiently great to justify their recognition as distinct sections.

Southern Sections of the Basin-and-Range Province.—That part of the Sonoran Desert which lies in the United States embraces the Mohave Desert at the northwest, the Gila Desert in the southeast, and the immediate basin of the lower Colorado in the center. The last is a very narrow strip if only that portion be included which actually yields surface water to the river. The Sonoran section differs from the Nevada Basin not only in its smaller proportion of mountains to plain, but in its lower elevation. It is bounded on the west by the Sierra Nevada and, south of that, by the Los Angeles Ranges and the Salton Basin. The line which separates the mountain provinces from the desert is essentially that which separates the older intrusive rocks from the Quaternary sediments. With the latter are included the small areas of pre-Cambrian which make the old block mountains. The boundary indicated on the accompanying map is located by this criterion but guided in detail by the fault lines shown on the map of the California Earthquake Commission.[59] The boundary of the Sonoran Desert against the Arizona (Mexican) Highland cannot be given exactly (see below).

A separate section is here made of the great trough, most of which is occupied by the Gulf of California, but whose northern end is the desert basin which centers in Salton Sink. It is bounded on the west by the Los Angeles Ranges and the Lower Californian Province. Its northeastern boundary is here drawn at the foot of the San Bernardino Range and of the other mountains (Chocolate Range, etc.) in line with the San Bernardino southeast to Colorado River. Southeast from Yuma, the boundary is so drawn as to leave the ranges, so far as possible, in the Sonoran section. That it is not possible in all cases to do this is seen from the high islands (mountains) in the Gulf of California in Latitude 29°.

The Mexican Highland is in the main a southeastward extension of the Nevada Basin, tho much of it is drained to the sea. In smaller part, it is the eroded margin of the Colorado Plateau stripped of its

[59] Atlas of California Earthquake Commission, Plate 1, 1908.

overlying beds. In the size of its block mountains and in the proportion of mountain to plain, this region resembles the Nevada Basin rather than the Sonoran Desert. In passing from this section southwest to the Sonoran Desert, the size and proportion of mountains decrease; hence there is gradation rather than a sharp line. However, despite this gradation, the contrast is quite enough to determine very different types of landscape which are well recognized and geographically important.

On the eastern margin of the Basin-and-Range Province is a narrow strip midway between Pecos River and the Rio Grande whose features suggest transition to the plateau type. This is the Sacramento section. Some of its basins have floors of horizontal sedimentary rocks not very deeply buried (perhaps several hundred feet) by Quaternary detritus. Some of the mountains, like the Sacramento from which the section is named, are simple, eroded, fault blocks, not like those in central Nevada, in which the strata are much deformed, but more like those of southern Oregon in which the tilt that raised the mountain is the only deformation noted.

Pacific Mountain System.

Sierra-Cascade Province.—The Sierra-Cascade Mountains form a continuous mountain mass from a little north of the Canadian boundary to the Mohave Desert in southern California. They cannot be called a single range if that word is made to imply unity of history or character. The 1,000 miles of mountains in this province embrace several distinct types.

Sierra Nevada.—The Sierra Nevada may almost be described as a fault block composed of old and much-deformed sedimentaries and intrusives, reduced by erosion to a low level, and then uplifted with a westward tilt. As thus defined, the range terminates in latitude 40° as shown by Diller.[60] In common usage the name Sierra Nevada is extended farther north, sometimes to the Oregon state line. This usage ignores the only important natural line of distinction.

As here indicated the northern limit of the Sierra Nevada is at the contact of the recent volcanic rocks on the north and the Paleozoics and older intrusives on the south. The eastern limit is marked thruout by fault lines. In drawing the accompanying map these faults have been followed, as shown on the Atlas of the California State Earthquake Commission, Map No. 1. Such lines are necessarily generalized and may represent as a single fault what should be several or many faults *en echelon.* Their importance here is not as faults but as scarps. Presumably the faulting is inferred from topographic evidence thruout most of the distance; hence the fault line as drawn is a good generalization of the mountain front. Beginning at the

[60] *U. S. Geol. Surv.*, 14th Ann. Rep., Pt. 2, Pl. XL.

north end just north of the 40th parallel, the boundary is a bold escarpment southwest of Honey Lake and Susanville. The line turns south along the California-Nevada boundary and, after a jog to the east, passes a few miles east of Lake Tahoe. Other faults lie west of this one. The basin of Lake Tahoe is in a *moat,* that is, on a depressed fault block between mountains on the west and east. South of Lake Tahoe the bold front is nearly straight, passing just west of Mono and Owens Lakes. Near the south end it curves to the west and runs at right angles to its upper course until it meets the Coast Ranges. On its west side the Sierra Nevada is essentially coextensive with the rocks older than late Tertiary.

Cascade Mountains.—For the first 150 miles at the south, the Cascade Range does not have that compactness of mass or definiteness of outline which is commonly thought of as belonging to a mountain range, and which is shown in a high degree by the Sierra Nevada and by the Cascade Range farther north. The Southern Cascade Mountains are a line of volcanic cones and plateaus of various sizes and ages, but all so recent that their height above the adjacent provinces is due to accumulation of eruptive material. Local relief is of course complicated with subsequent erosion features. The distribution of the volcanic vents is very irregular and the accumulations vary greatly in depth. Huge accumulations like those marked by Shasta and Lassen Peak, alternate with sags. By one such sag Pitt River crosses the range.

At their south end for perhaps fifty miles these mountains are bordered on the west by the Valley of California. Within this distance the volcanic accumulations fail to cover completely an eroded belt of Tertiary strata which here constitute a belt of foothills which are necessarily included in the mountain province. Farther north the volcanic accumulation lies against or upon the Klamath Mountains. Here the western boundary of the Southern Cascade Mountains is at the edge of the volcanic rocks. For sixty miles in northern California this boundary is approximately marked by the valley which is followed by the Southern Pacific Railroad, but both north and south of this stretch the province boundary is farther east.

A conventional western boundary is thus assigned to the Southern Cascades, based on geologic contacts. On the eastern side of the range, if range it may be called, such a boundary is not possible because the rocks of the adjacent Nevada Basin are likewise volcanics not yet distinguished on geologic maps from those which make the mountains. Here the boundary must be fixed by topographic data without relation to geologic lines. It is necessarily much generalized. The line here used is taken from Diller.[61]

[61] J. S. Diller: *U. S. Geol. Surv.*, Bull. 196, Pl. I, p. 9.

West of Klamath Lake (latitude about 42° 15′) the Cascade Range becomes well defined on both sides and continues so to the north. Evidences of faulting appear, indicating that the range here owes part of its relative altitude to crustal uplift. This portion of the range is the Middle Cascade Mountains. It extends north nearly to latitude 47° 30′. These mountains are completely covered with volcanic rocks and owe their height at least in part to extensive accumulation. Presumably this factor is very large, but of decreasing importance toward the north, for at the northern end of this section the volcanic cover gives out while the height of the range continues undiminished. Where cut across by Columbia River the component lava sheets are distinctly, tho not sharply, folded and indicate uplift along the axis of the range. The northern end of this section is also characterized by a close accordance of summit levels which has been interpreted as evidence of an uplifted peneplain, thus assuming crustal movement as it is not assumed in the Southern Cascades. With respect to this feature also, it appears that there is gradation between the southern and northern ends of the middle section.

The eastern foot of the Middle Cascade Mountains in Oregon is a fairly definite topographic line. The range overlooks the valley of Klamath Lake and Williamson River, and, for about 175 miles, the nearly straight valley of Deschutes River. North of the Columbia, the eastern slope of the range is complicated by subordinate transverse folds making low swells which extend east from the range. Some of these are much dissected, but on the whole it seems most consistent to interpret the plateau province somewhat liberally and to exclude these east-west swells from the mountain province. The line on the accompanying map is a generalization from the topographic sheets of the United States Geological Survey.

On the west the Middle Cascade Mountains descend to the Puget trough, including its southern portion, the Willamette Valley. Accurate topographic and geologic maps along this boundary are wanting. The line here used is based on the contour map of the United States (40 miles to the inch, 1913). From available topographic and geologic maps it does not appear that the topographic break follows any one geologic line consistently. Farther south these mountains are bounded by the Oregon Coast Range section and the Klamath Mountains, the Cascade Range being limited to the area of volcanic rocks.

The Northern Cascade Mountains differ from the Middle and Southern in having no cover of recent volcanic rocks. Their accordant crests suggest a maturely dissected peneplain and, in any case, their altitude is necessarily due to crustal movement.

The eastern boundary of this section is approximately at the Colum-

bia and Okanogan Rivers. The latter stream is bordered on both sides by a belt of lower mountains and hills which are much more like the adjacent low Rocky Mountains than like the Cascades. On the accompanying map an attempt has been made to throw these in with the Rocky Mountain Province by locating the boundary a few miles west of Okanogan River. (See p. 83.) The boundary on the west against the Puget trough is like the corresponding boundary of the Middle Cascades. Geologic lines are not determinative. The line on the accompanying map is taken from available topographic sheets supplemented by the contour map of the United States. A few miles north of the International Boundary the Cascade Mountains end. Beyond them is the Interior Plateau of British Columbia, the southernmost representative of a plateau belt in Canada and Alaska.

Pacific Border Province.—The Puget Trough is an intermontane valley 400 miles long within the United States and extending far to the north between the coast of British Columbia and the adjacent islands. Its south end is the valley of the Willamette. Its boundary on the east has already been described. The western boundary must in like manner be described empirically for the present. It is not known to coincide with any geologic line. It is drawn at the foot of the Olympic Mountains and the Oregon Coast Range. The altitude of the mountain foot varies from a little more than 100 feet at the north to more than 500 feet at the south. The Puget Trough is limited on the south by the Calapooia Mountains, a spur connecting the Cascades and Oregon Coast Range. This transverse range forms the divide between the longitudinal Willamette on the north and the transverse Umpqua on the south. The section boundary is not, however, on the crest of the divide but at the northern foot, since the range is necessarily in one of the mountain sections.

The California Trough lies west of the Sierra Nevada and Southern Cascade Mountains. The boundary on this side has already been described. The western boundary of the trough is similar to the eastern, namely, the line of contact between the Quaternary sediments of the valley floor and the older rocks which participate in the structure of the California Coast Ranges.

The Olympic Mountains of Washington are an isolated group. West of longitude 123° 30′ the northern base of the mountains is essentially at the shore of the strait of Juan de Fuca. Farther east and on the east side, the mountain section is bordered by a low margin of Quaternary sediments which belongs to the Puget Trough. On the west side is a dissected coastal plain ten to twenty miles in width which must be included in the same section with the mountains. With more detailed work in the future, this and other parts of the narrow coastal plain, as far south as latitude 43°, may be made divisions of a lower

order than those now recognized. A similar plain borders the Olympic section on the south and is included in it, Chehalis River being taken as the boundary.

The Oregon Coast Range can scarcely be called mountainous. It is rather a dissected plateau, but none the less range-like and a distinct uplift above the Puget Trough on the one side and the narrow coastal plain on the other. The latter is included in this section. The Oregon Coast Range extends from Chehalis River (Olympic section) on the north to the Klamath Mountains on the south. On that side the boundary is at the contact of the Tertiary rocks of the Oregon Coast Range with the older rocks to the Klamath.[62]

The features of Klamath Mountains are conditioned by old rocks closely folded, generally metamorphised and strong. They rise above their neighbors on the north and south, tho not above the Cascades on the east. On the south they touch the California Coast Ranges, all rocks younger than Paleozoic being classed with the latter. The Klamath Mountains are thus bordered on all sides by mountains which differ from them in topography because of differences in the rocks which compose them.

The name California Coast Ranges is here used in the sense most commonly understood, namely, to designate the mountains along the coast having a north-south or northwest-southeast trend. This excludes what are called below the Los Angeles Ranges, the most prominent of which have an east-west trend. The line of separation between these two sections is not sharp because of the curving of axes near the boundary. The two sections are here separated along the line of Santa Ynez River.

The section here called Los Angeles Ranges includes not only the Santa Ynez, San Gabriel, and San Bernardino, which have a distinct east-west trend, but other ranges south of them (Santa Ana, San Jacinto, etc.) whose trend is more southeasterly. The latter are blocks between parallel faults affecting the great granitic mountain area of Lower California. South of the east-west ranges are the lowlands sometimes spoken of as the Valley of Southern California. This more or less continuous lowland is in part coastal plain and in part intermontane valley between the more southerly ranges whose trend intersects that of the San Gabriel and the San Bernardino.

Lower Californian Province.—The Lower Californian Province is the great granitic area, at least in part mountainous, which lies mainly in Lower California. It is similar to the Sierra Nevada, being limited on the east by a sharp descent (presumably a fault scarp) to the Salton Trough. As here set off, the section consists of a broad west-

[62] J. S. Diller: *U. S. Geol. Surv.*, Bull. 196, Pl. I, p. 9.

sloping upland, not of parallel mountain ridges. The parallel fault ridges at its north end, which are geologically a part of the same province, are for this reason classed with the Los Angeles Mountains. The line here presented follows Santa Marguerita River and the most southerly of the well-marked faults, as shown in the Atlas of the California Earthquake Commission (1908).

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THE PREVAILING WINDS OF THE UNITED STATES[1]

ROBERT DE C. WARD

CONTENTS

Importance of Winds in Economic Climatology.—To our prevailing winds we owe many of the larger characteristics of our climates. Winds import temperatures and moisture from a distance. If their way is not obstructed by mountain barriers, they tend to produce uniformity of climates over extended areas. They effectively wipe out many climatic boundaries. They bring marine conditions on shore. They carry land conditions off shore. They largely determine rainfall, and thus control the distribution of life. They bring us clean. pure air and are active agents in promoting health. Or, by carrying dust and micro-organisms, they may contribute to the prevalence of disease.

Wind velocity, too, apart from wind direction, has many human relations. The difference in our feeling of physical comfort or discomfort largely depends upon the amount of wind movement. The more extreme manifestations of wind force damage buildings and crops; wreck vessels; endanger or destroy human life. A knowledge of the highest velocities that are likely to occur is essential in the work of an engineer or of an architect, in the planning and the construction of buildings and of bridges.

As a source of power, winds are attracting more and more attention. We have in the United States scores of firms whose sole business it is to make windmills, hundreds of thousands of which are already in use. It is a significant illustration of the climatic control of the location of an industry that most of these windmill plants are situated in the open country of our middle west, where there is effective wind movement. American inventors have perfected powerful steel wind-

[1] Presented (in abstract) before the Association of American Geographers, Washington, December, 1915.

mills which are self-adjusting to varying wind directions and velocities; they make the maximum use of the minimum effective wind movement, and automatically turn out of the wind when the velocity becomes too great. In use over large sections of the United States where the wind velocities have proved themselves to be most usable and reliable, our windmills are to-day pumping water for irrigation, for cattle, and for domestic uses; they are grinding corn, cutting wood, and churning. The time is probably not far distant when these windmills will be used to generate electrical energy, which, when stored and accumulated, will supply us locally at a minimum expense with heat, light and power. In times of slack wind, combustion engines, started automatically, or storage batteries, may be used to keep up the supply of electricity. Our wind velocities have proved themselves a climatic asset of whose value we have, for the most part, been strangely unconscious. They have a very real human significance.

General Relations of Pressures and Winds: Cyclonic and Topographic Controls.—The continental area of the United States lies almost entirely within what is generally known as a belt of "prevailing westerly winds." These are members of the general atmospheric circulation. They would, however, blow from a general westerly direction much more distinctly if there were no North American continent with its seasonal changes of temperature and of pressure; with its mountains and its lowlands; with its Great Lakes and its storms, to interfere with them. The local influences of the changing seasonal pressures over the continent and over the adjacent oceans are, to a large extent, paramount to the general control over air movement exercised by the differences of pressure between the equator and the higher latitudes. To the south, the states bordering on the Gulf of Mexico, subtropical already in latitude, share also in the wind system which is characteristic of tropical countries, i. e., the trades. These trade winds, like the prevailing westerlies, find their initial cause in the great permanent differences of temperature and of pressure between equator and poles, but over the southern United States, as in other regions also, are greatly modified by the local pressure distribution.

Year after year the orderly succession of the seasons brings a warming and cooling of our continent. The pressures change systematically, not only over the continent itself, but also over the adjacent oceans. And, sympathetically also, our prevailing winds show a seasonal change in their directions. But other influences play their part. Our great mountain systems are barriers in the path of the winds. Mountains turn winds aside, as in the case of the prevailing westerlies off our southern Pacific coast in winter, noted by Ferrel[11]; or cause them

to flow around the obstruction, as in the case of northwest and southeast winds in the Appalachians[2]; or otherwise serve as divides between winds of different directions and characteristics. The general configuration of the country; the trend of mountains and of valleys; locations to windward or to leeward of mountains or of lakes; the hour of the day or night; exposure to land and sea breezes: all these factors have a part in controlling our winds, both in direction and in velocity. Then, varying from day to day, more temporary than any of these other controls, comes the ever-changing influence of our cyclones and anticyclones. The dominance of these passing conditions over our air movements is often so complete that *easterly* winds are of frequent occurrence thruout the belt of our prevailing *westerlies*. Many persons, indeed, especially along or near our northern Atlantic coast, find it difficult to believe that our prevailing winds are really from the west[3]. Easterly storms; easterly winds blowing on shore from a high-pressure area off the coast; even the local and relatively insignificant sea breeze, all combine to keep up this impression. Frequent as are the interruptions of our prevailing westerly winds near the surface, the upper currents follow their regular course from the west with remarkable persistence. The clouds which they carry tell us this story. And so do the observations from Mt. Washington, Pike's Peak, and other elevated stations. The relation between our temporary cyclonic and our prevailing westerly winds was clearly recognized by Blodget[4], who also saw the evidence of prevailing winds from west to east in the trend of the isotherms and in the difference in temperature and humidity on the Pacific and Atlantic sides of the continent.

The wind direction and velocity at any station, as shown on our daily weather maps, depend upon the controls just referred to, together with others, such as the local exposure of the wind instruments, e. g., their height above the ground, the influence of adjacent buildings, etc. Many of our stations show quite persistent influences of local topography upon their wind directions, resulting from the position of a neighboring mountain; the trend of a valley, or from exposure to local mountain and valley winds[5]. The winds at our northern stations, for example, are more affected by storm controls than those farther away from the main storm paths. The wind directions shown on our weather maps are, therefore, the complex resultant of many variables. The wind arrows on these maps, as well as on the usual charts which show the monthly or annual prevailing wind direction at each Weather Bureau station, emphasize the local peculiarities of each place. They do not give us the broadly generalized view of our winds which we often need in a study of our larger climatic conditions and of their controls. What we here want to know is the general

sweep of our winds, i. e., our wind systems, over the different sections of the United States. In Figs. 1 and 2 the prevailing winds for January and July are thus broadly generalized. No attempt is made to show details, or to ensure absolute accuracy of direction over every portion of every State. The purpose is only to give a general view of the larger wind movements. The effects of local topography have, so far as is reasonably possible, been disregarded, and in cases where several wind directions have almost equal percentages of frequency, the prevailing direction has been taken to be that which agrees with the general conditions of wind movement over neighboring districts. Useful as such generalized wind charts are in a climatological study, it must constantly be borne in mind that the interference with these prevailing wind directions, under temporary cyclonic and anticyclonic control, is both important and frequent, especially in winter, and over the northern tier of states.

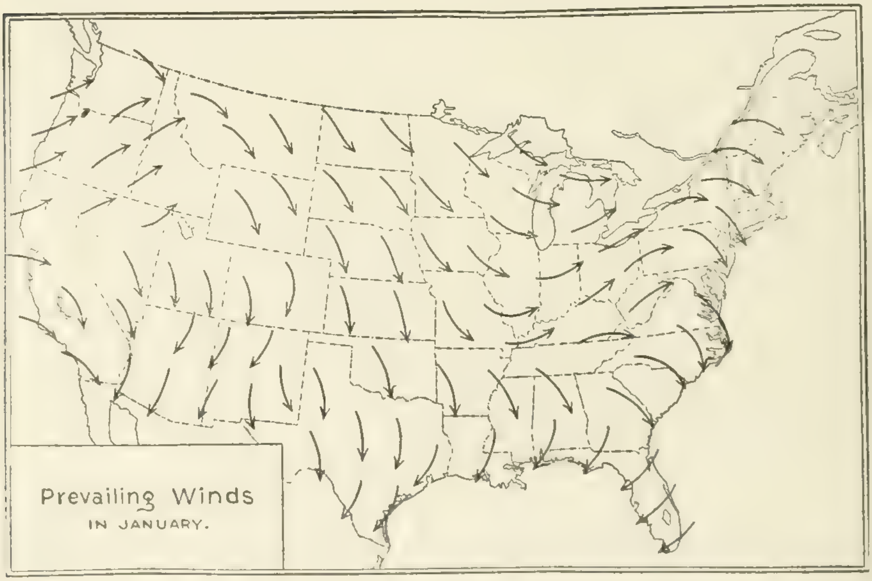

FIGURE 1

JANUARY WINDS.—Our winter winds are markedly under the control of a seasonal pressure distribution peculiar to North America. This is less fixed, less clearly defined, more complex than that of Eurasia. Hence our winter wind systems are also less emphatic. We have no great dominating winter anticyclone. Generalizing broadly, and summarizing very briefly, the tropical high-pressure belt over the adjacent oceans expands over the North American continent into a ridge of high pressure (30.20 ins.), lying between the well-marked low-pressure areas of the northern North Atlantic and

northern North Pacific[6]. In response to this mid-winter pressure distribution certain large and fairly easily recognizable wind systems are developed. Taken as a whole, the centrifugal tendency, characteristic of continents during their winter season, is at once apparent.

In the eastern United States ("Eastern Province") northwesterly offshore winds generally prevail along our northern and middle Atlantic seaboard, under the combined control of the low-pressure system which overspreads the northern part of the Atlantic Ocean, extending as an elongated trough from northeastern North America (Davis Strait and Baffin Bay) to northwestern Europe.[2] These northwesterly winds increase in velocity and in frequency as we go farther north into New England, and still more so outside of our own territory in northeastern Canada, where the North Atlantic low-pressure system exerts a more marked control. They become less marked towards the south, where there is an increasing tendency towards westerly and southwesterly and, especially on the coast of the southern Atlantic States, even toward northeasterly and northerly directions. We owe the severe winters of our middle and north Atlantic coast states to these offshore winds. They come from the cold northern interior. They cause discomfort and often much suffering among those who are unable to secure proper protection in the way of clothing, heat, and adequate food. But to these same cold winds we owe the ice supply from our northern lakes and ponds and rivers, so indispensable during our hot summers. They also very greatly increase our need of fuel for heating purposes, and thus enormously stimulate our coal industry, with its resulting demand for labor and for railroad and steamship transportation.

The influence of the Atlantic Ocean is felt when our winds blow onshore under the control of some passing high or low-pressure system. These easterly winds temporarily interrupt the prevailing offshore movement of the air. They bring us our chilling northeast snowstorms, and our warmer, often rainy, southeasterly and southerly storm winds. Such interruptions of the offshore tendency are frequent in the eastern United States, where our storm control is marked. Our winter winds and weather are hence very changeable. In eastern Asia, on the other hand, where the general seasonal pressure control over the winds is more emphatic, and where the storm control is relatively less important, the northwesterly winds remain in much less disturbed possession. There the latter are indeed so marked that they deserve the name of winter monsoons. Eastern Asia, for this reason, has drier and less cloudy winters than those which characterize our Atlantic seaboard.

A comparison with Europe also naturally suggests itself. While our

[2] The climatic provinces which are used as the basis of the discussion in the present paper are those suggested by the author in his "Climatic Subdivisions of the United States," *Bull. Amer. Geogr. Soc.*, Vol. XLVII, Sept., 1915, pp. 672-680.

own Atlantic coast is having its severe winters, western, and especially northwestern, Europe are kept abnormally mild and temperate because their prevailing southwesterly winds are blowing from the warm Atlantic Ocean and from more southern latitudes. Thus the eastern and western sides of the North Atlantic inevitably differ greatly in climate. Similar temperatures are met with, not in the same, but in widely separated latitudes. As seen on the chart of mean annual temperatures, one may go north in western Europe a thousand miles without finding as great a decrease in temperature as that met with in half that distance on the eastern coast of North America. Northwestern Europe is to be compared with our northern Pacific coast, and with British Columbia, not with our Atlantic coast. Europe is singularly favored in its exposure to these warm winter winds.

For the sake of clearness and of simplicity in dealing with the prevailing winds, we may divide the interior of the United States ("Eastern Province") east of the Great Plains and north of the "Gulf Province," into "Ohio Valley and Lower Lakes" and "Mississippi Valley west." Prevailing southwesterly and westerly winds characterize the former of these two divisions; northwesterly and northerly winds prevail over the latter. The northern portion of the Upper Lakes shares in the wind system of the latter district[7]. In the States bordering on the Gulf of Mexico ("Gulf Province"), Florida has prevailingly northeast winds (Trades); while northerly directions predominate along the northern and western shores of the Gulf. There is also a considerable southerly (S. E.) component in the western Gulf coast section, although this is not shown on the map (Fig. 1). All across the broad expanse of our Great Plains ("Plains Province"), and even into the western plains of Canada, the great northerly and northwesterly sweep of winds, noted as characteristic of the States just west of the Mississippi River, continues as a dominant climatic feature. Over the northernmost section, and across the Canadian border, a tendency towards gentler wind movement, with many calms, is observable.

It is difficult to generalize the winds in the region between the Rocky Mountains and the Sierra Nevada-Cascade system ("Plateau Province"). Here the enclosing mountain barriers and the broken topography greatly interfere with a free sweep of the winds. Over the southern portion of the district ("Southern Plateau"), blowing out from the continent, northerly wind directions are frequent, while, under the control of the general pressure distribution, southwesterly winds are most common farther north ("Northern Plateau"). Shut off by the high barrier of its eastern mountains, the Pacific slope ("Pacific Province") has its own wind system, prevailingly from the southwest and west along shore. These winds are chiefly under the

control of the marked low-pressure area of the North Pacific, but the tropical high-pressure belt, lying farther south, also influences the wind directions, especially along the southern portion of the coast. In the interior, notably in California, wind directions are greatly modified by topography. It is to its prevailing westerly winds, coming directly from a conservative ocean, that our Pacific slope owes the far-famed mildness and equability of its winters. Warm winds blow there most of the time in the cold season, while on the Atlantic seaboard, it will be recalled, the prevailing winter winds (northwest) are the coldest that can blow. Hence the latter province has notably severe winters, especially in northern sections. The passage of winter storms, chiefly over the northern Pacific coast, or the presence of a high-pressure area to the east or northeast, brings temporary easterly winds in Washington, Oregon and California. On the Pacific slope, northeast winds in winter come from a cold land, and bring low temperatures. On the Atlantic coast they are damp, and usually bring rain or snow.

The following table gives a compact summary of the generalized prevailing winds of the United States in winter (January). All details are disregarded. Only the broadest features of the wind systems are indicated.

COMPACT SUMMARY OF THE PREVAILING WINDS OF WINTER

Eastern Province:
- a. Atlantic Coast: N.W., W.
- b. Ohio Valley and Lower Lakes: S.W., W.
- c. Mississippi Valley west: N.W., N.

Gulf Province:
- a. Eastern (Florida): N.E.
- b. Central: N., N.E.
- c. Western (Texas): N., N.E., S.E.

Plains Province: N.W., N.

Plateau Province:
- a. Northern: S.W.
- b. Southern: N., N.W.

Pacific Province:
- a. Northern: S.W., W.
- b. Southern: W., N.W.

July Winds.—Our wind maps are misleading if we think of them as representing anything fixed or settled. They are really only "snapshots" of conditions which are in a more or less constant state of

transition. Our prevailing winds are great sweeping currents, under the control of seasonally changing pressure distribution. The winds for January and July are chosen for discussion because these are our midwinter and midsummer months, and their winds are fairly characteristic of these two seasons. But all the year through a gradual shift is taking place, from the conditions of one month to those of the next. January and July are only temporary stages on the way. We wholly fail to appreciate what these seasonal and monthly changes mean unless we can imagine our winds in this constant state of transition.

Continental and marine pressure conditions different from those of winter have a marked effect in controlling the general flow of our summer winds. A low-pressure trough (29.75 inches at the centre) extends across western North America, roughly from north to south, merging on the south with an east-and-west belt of low pressure over Central and northern South America. The North Atlantic high-

FIGURE 2

pressure belt overlaps the continent in the southeast, and the Pacific high-pressure area, with crowded isobars on its eastern side, encroaches on the land along our Pacific coast. The two ocean high-pressure systems, which form part of the so-called tropical high-pressure belt, are thus separated by the continental trough of low pressure. From the cooler oceans onto the warmer land the winds tend to blow centripetally, guided by these seasonal pressures, the unchanging topography, and the temporary storm control. From midwinter to midsummer,

taking place gradually, as winter merges into spring and spring later merges into summer, there is a great swing of the winds over the eastern United States, from the prevailing northerly and northwesterly directions of January to a prevailing southwesterly and southerly direction in July. Southerly winds gradually advance northward and eastward from the Gulf of Mexico as spring comes on, until, by early summer, they prevail (as southerly or southwesterly winds) over practically the whole of the United States east of the Rocky Mountains. In July, the Atlantic coast and most of the Ohio Valley and Lower Lakes district have prevailing southwesterly winds, under the combined control of the North Atlantic high and low-pressure systems. This seasonal change in direction is most marked along the Atlantic slope. In the Ohio Valley and Lower Lake district, the prevailing wind directions are essentially the same in summer and in winter, the general pressure gradient being in about the same direction thruout the year. Supan has shown the seasonal wind changes along our Atlantic coast by means of the following table[8]. The minus (—) sign indicates a decrease in that particular wind direction from winter to summer. In the northern section, the change is mostly between northwesterly and southwesterly; in the southern, mostly between north and south. Hence it is more marked, i. e., it covers a larger number of degrees, in the south.

CHANGES IN WIND FREQUENCY (%) FROM WINTER TO SUMMER (SUPAN).

District	N	NE	E	SE	S	SW	W	NW
Northeastern Coast	— 5	—2	1	4	7	14	—3	—16
Middle Atlantic Coast........	— 2	—3	0	6	8	7	—2	—14
South Atlantic Coast.........	— 7	—4	3	8	7	4	—1	— 9
Northern Gulf Coast.........	—10	—6	0	3	5	9	3	— 5

Von Hann has summarized the winter and summer wind directions (in percentages) on the eastern coast of North America, in middle latitudes, as follows[9]:

FREQUENCY OF WIND DIRECTIONS (%) IN MIDDLE LATITUDES ON THE EASTERN COAST OF NORTH AMERICA (VON HANN).

	N	NE	E	SE	S	SW	W	NW	Resultant
Winter	11	15	6	6	7	18	14	23	N 58°W
Summer	8	12	6	11	13	28	9	13	S 45°W
Difference	3	3	0	—5	—6	—10	5	10	

The dominance of the winter northwest winds, and of the summer southwest winds, is clearly seen here. With the seasonal change from summer to autumn, and then to winter, the northwesterly winds advance from the continental interior toward the south and east until

they, in their turn, dominate the region of the Plains, the Mississippi Valley west, and much of the Atlantic Coast.

The Gulf States ("Gulf Province") are crossed by what may perhaps be called a branch of the northeast trades which, under the control of the Atlantic high-pressure area and of the lower pressure over the continent, become southerly or southeasterly winds. The States lying immediately west of the Mississippi Valley, and the Great Plains ("Plains Province"), are crossed by a great sweep of southerly and southeasterly winds, which extend north even across the Canadian line. Professor A. J. Henry has pointed out that, in late spring, the southerly winds of the Mississippi Valley apparently divide over the Great Lakes into two branches, one forming part of the summer southerly and southeasterly winds of the Missouri Valley and the Plains, and the other forming part of the southwesterly winds of the Ohio Valley system[10]).

This great body of moist southerly air, after crossing a wide expanse of warm Gulf and Atlantic waters, blows inland over the eastern United States around the western margin of the North Atlantic high-pressure area. To it we owe most of our beneficent warm season rains and thundershowers. Without these our important staple crops east of the Rocky Mountains would never reach maturity. To these same winds, coming from warm southern latitudes, our hot eastern summers are chiefly due. Thus the prevailing summer winds along our Atlantic seaboard (S.W.) are our warmest winds. Except when temporarily interrupted by easterly winds from the ocean (see p. 103), or by northwesterly winds from higher and cooler latitudes, they assure us a preponderance of high temperatures. The tempering influence of the Atlantic has little opportunity to make itself felt. Our warm southerly summer winds bring us our sunstroke weather; our epidemics of cholera infantum; our spells of suffering in our crowded cities. The development of summer resorts in the north, among the mountains, and on the seacoast, is in no small degree due to these same warm winds. Sea bathing and electric fans, thin clothing and cooling beverages, find much of the explanation of their use and enjoyment in the fact that the dominant winds of our eastern summers are the warmest winds that we can have. In recent years, economic consequences of no small importance have been attributable to these same southerly winds. In New England, the brown-tail moth, a pest which had already done great damage to fruit and other trees in Massachusetts, was spread northward and eastward over the adjoining States by the southwesterly winds. And in Texas, the cotton boll weevil, another pest of serious economic importance, was also spread northward by the prevailing southerly winds of that region.

A comparison with Europe is interesting. Western and northwest-

ern Europe have their prevailing summer winds from a cool ocean and a higher latitude. On our Atlantic coast the prevailing summer winds are from a warm land and a lower latitude. Hence, in Europe, the tempering influence of the conservative Atlantic largely counteracts the warming influence of the land, while along the eastern seaboard of the United States the land influence predominates. Our severe eastern climates, with their cold winters and hot summers, largely find their explanation in the directions of our prevailing winds.

Over the "Plateau Province" the winds of summer show a tendency toward northerly and northwesterly directions in the north, while in the south, southerly directions prevail. As in winter, however, the enclosing mountain barriers of this region, and the local topography, greatly interfere with the development of broad, sweeping wind systems. Local mountain and valley winds, their direction determined by the immediate topography, are characteristic phenomena. They often exercise an important control over the conditions of frost occurrence.

Supan has summarized the changes in wind direction from winter to summer for certain districts west of the Mississippi River in the following table[8]. The minus (—) sign indicates a decrease in that particular wind direction from winter to summer.

CHANGES IN WIND FREQUENCY (%) FROM WINTER TO SUMMER (SUPAN).

District	N	NE	E	SE	S	SW	W	NW
Upper Mississippi Valley.....	— 2	1	2	3	4	3	—3	— 8
Upper Missouri Valley.......	—11	2	7	9	11	1	—8	—10
Arkansas and Red Rivers and Texas	—15	—4	5	21	11	—1	—5	—12
Lower Colorado River........	—28	—6	2	14	26	6	—2	—11

The decrease in the northerly and the increase in the southerly directions from winter to summer is striking, especially in the case of the last-named district, where the change is almost monsoonal in character. The annual reversal of the wind system at Yuma, Ariz., is shown in the following table[11].

RELATIVE FREQUENCY OF THE WINDS (EXPRESSED IN PERCENTAGES) AT YUMA, ARIZ., AS DEDUCED FROM TRI-DAILY OBSERVATIONS, 1876-1888.

January....................	N 28	NE 19	NW 14
July.......................	S 23	SE 21	SW 19

On the Pacific Slope ("Pacific Province") the summer winds are westerly, as in winter, but the northerly component is more marked in the warm season, the southerly in the cold. The prevailing northwesterly winds of summer are so regular, especially toward the north (e. g., Oregon), that they are often locally known as trade winds.

The change from winter to summer is due to the combined influence of the warm continent and of the more northerly summer position of the Pacific high-pressure system. From winter to summer there is a loss in northeast, east and southeast winds, and a gain in west and northwest winds. This is in part attributable to the frequent cyclonic and anticyclonic winds from easterly points during the winter season. The coast mountains tend to deflect the winds along the shore. Thru the Golden Gate, at San Francisco, the winds blow into the hot Valley of California, and are there turned north and south. The southerly winds of summer are a marked climatic feature of the Sacramento Valley. They serve somewhat to moderate the heat of that well-enclosed and easily warmed district. And they are so steady that boatmen on the Sacramento River can count on them for sailing upstream.

The prevailing summer winds along the Pacific coast are dry, because, blowing out on the eastern side of the North Pacific anticyclone, they have had no opportunity to take up much moisture, and furthermore they are advancing into lower latitudes and therefore warming. The contrast between the prevailing damp and warm summer winds on the western side of the North Atlantic high-pressure system, and the drier and cooler winds on the eastern side of the North Pacific high-pressure system is striking, and climatically very significant. It is also significant that the prevailing summer winds on our Pacific coast come from a cool ocean and higher latitudes, just as is the case, already noted, in northwestern Europe. In the United States, however, our western mountains practically limit the moderating influence of the westerly winds to a comparatively narrow belt between the Sierra Nevada-Cascade barrier and the Pacific Ocean, and the transition from the more moderate conditions of the immediate sea coast to the more extreme climates of the interior is rapid and sharp. In Europe, on the other hand, there is a very gradual transition from the marine climates of the outermost western coastal strip to the more severe continental conditions of Russia. Again, in Europe there are very uniform climatic conditions over all the Mediterranean region, from Portugal and southern Spain across Italy and Greece, and even into Asia Minor. Civilization in the Old World was therefore able to spread westward from the Orient over a large area of remarkable climatic uniformity. In North America a similar "Mediterranean climate" is found only over a relatively narrow zone, essentially in central and southern California. The smaller area of the subtropical belt of Mediterranean climates in North America than in Europe was clearly explained by Blodget[12]. "If the Gulf of Mexico were similar in position to the Gulf of California, yet extended inland like the Mediterranean, the districts of the various local pecu-

liarities now bordering on the Mediterranean would be reproduced. . . . The space where we may look for phenomena correspondent to those of the Mediterranean is here relatively small."

The prevailing winds of summer, broadly generalized, may be briefly summarized as follows:

COMPACT SUMMARY OF THE PREVAILING WINDS OF SUMMER

Eastern Province:

a. Atlantic Coast: S.W., W.
b. Ohio Valley and Lower Lakes: S.W.
c. Mississippi Valley west: S.E., S.

Gulf Province: S., S.E.

Plains Province: S., S.E.

Plateau Province:

a. Northern: N.W.
b. Southern: S.

Pacific Province: N.W., W.

Our American Monsoons.—Monsoons in the Indian sense, of great seasonally inflowing and outflowing winds, strongly contrasted in direction and in characteristics, and markedly controlling the life and activities of all the people, we cannot claim. Yet that a distinct monsoonal tendency exists over a large section of our country was clearly noted at least as far back as the time of Blodget, who wrote of the winds of Texas, as "something very near a monsoon[13])." Later (1875) Coffin discussed, in a general way, the monsoonal tendencies in our winds[14]). And Ferrel, fifteen years later, considered the conditions which give rise to monsoons and referred to the monsoon influence on the winds of the southern United States and of the Gulf of Mexico[15]). The general swing from northerly winds in winter to southerly winds in summer over the Great Plains and eastward to the Mississippi River (see p. 107), is especially well marked in the south (e. g., Texas). Here, as pointed out by von Hann, the seasonal variation of relative humidity is most analogous to that of southern and eastern Asia. The weaker general pressure controls, and the frequent cyclonic interruptions of these seasonal winds in the United States, prevent any such marked development as that attained by the monsoons of India. Our Texas monsoons have been studied by Professor M. W. Harrington, who also used the name monsoons for the seasonally changing winds on the Pacific coast south of San Fran-

cisco[16]. The northerly (winter) monsoons first appear distinctly in December. While having generally a higher velocity than those of the summer, they do not maintain themselves under unfavorable conditions. They are not infrequently strengthened, under temporary conditions of rapid pressure change, into a northerly gale of high velocity, known as the "norther." This wind is one of the marked characteristics of Texas climate, even far out onto the western Texas plains. At times, "northers" reach as far south as Guatemala and Honduras; cross Tehuantepec, and are reported by ships in that portion of the Pacific Ocean. In midsummer a territory about 500 miles wide and about 1,000 miles long, reaching as far as the Canadian boundary, is under the general control of the southerly (summer) monsoons. These are weaker than those of winter, and bring clear weather, unless a low-pressure area is approaching. East of the Mississippi and south of the Ohio there is no good evidence of them except on the Gulf coast, as far as Mobile. These southerly or southeasterly winds are welcome cooling agencies during the heat of the Texas summer, even at considerable distances from the coast of the Gulf of Mexico.

Geographical Distribution of Wind Velocities in the United States.—Accurate charts of our average wind velocities are difficult to draw. There have been many changes in the locations and in the exposure of our anemometers. Especially has this been true in our large cities, where the increasing heights of our sky-scrapers have made the placing of these instruments on the lower buildings less and less desirable. As the anemometers have been exposed on the tops of higher and higher buildings, the recorded wind velocities have become greater and greater. Fig. 3 shows the average hourly velocity of our winds as determined by Mr. P. C. Day, of the United States Weather Bureau[17]. The figures indicate the hourly wind velocity estimated for the uniform elevation of 100 feet. A "correction" has been applied to allow for the retardation of the winds by the buildings of our large cities.

In the eastern United States ("Eastern Province") stations close along the Atlantic coast and on the Great Lakes have the most wind. The line of ten miles an hour closely parallels the margins of these bodies of water. Somewhat higher winds (10-14 miles an hour) prevail at the most exposed points on the Atlantic seaboard, e. g., at Cape Cod, Mass., and Cape Hatteras, N. C., and also to the leeward of Lakes Erie and Ontario. In the "Gulf Province," many coast stations have about the same wind movement as that of the Atlantic and Great Lakes stations. The small amount of friction over water, and exposure to frequent storm winds, account for these high velocities. Lashed by

winter gales and autumn hurricanes, the waters off Cape Hatteras are proverbially rough. It is but natural that such meteorological handicaps to navigation should have led to the digging of the Cape Cod Ship Canal, completed in 1914, and to the project of constructing a protected waterway for vessels among the islands and across the lagoons and bays along the Atlantic coast farther south. The popular designation of a windy city, often confined to Chicago, applies with equal truth to other stations on the Great Lakes and the Atlantic coast.

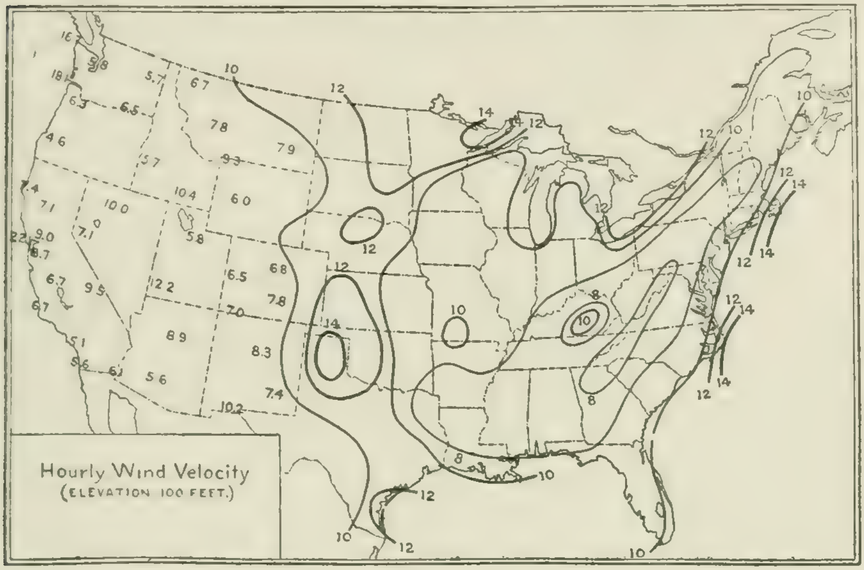

FIGURE 3

Over the interior, away from large bodies of water; among the mountains; in forests; in sheltered valleys, lower wind velocities are the rule. Exposed mountain tops, like Mt. Washington, N. H. (about 6,300 feet), are much windier. The Mt. Washington records have shown velocities averaging over twenty-five miles an hour in summer, and over thirty miles in winter. Mt. Weather, Va. (1,700 feet), and Mt. Mitchell, N. C. (6,700 feet), have much less wind because they are farther away from the northern storm paths.

Very striking is the broad zone of the Great Plains ("Plains Province"), with wind velocities closely resembling those along the eastern seaboard and the Great Lakes—winds which are ocean-like in character, as vast stretches of the Plains are themselves ocean-like in their monotony and in their unbroken sweep to the far-away horizon. No more striking illustration of the wind velocities on the Great Plains have ever been given than Captain Lewis's description of the occasion, on the famous Lewis and Clark Expedition, when one of his boats,

which was being transported on wheels, was blown along by the wind, the boat's sails being set! Surely this story emphasizes the analogy between the winds of the ocean and the winds of the Plains. Over this great treeless open country, but little retarded by friction, blow winds of remarkable uniformity and of relatively high velocity, averaging ten to twelve miles an hour, and even reaching fourteen or fifteen miles in the region of the Texas "Panhandle." Pike's Peak (14,134 feet), although more than twice as high as Mt. Washington, has much less wind than the New Hampshire summit because it is in a region of much less marked cyclonic control. The average velocities are 22 miles an hour for the year; 27.1 in March; 13.5 in July.

It is a climatic fact of great economic importance that the wind velocities over the Great Plains are so extraordinarily well adapted for driving wind-mills. The configuration of the continent, and the distance from primary sources of moisture supply, result in giving this great interior region a somewhat deficient rainfall. It is a district over most of which general farming without irrigation is a hazardous undertaking. To secure water for irrigating, for stock, and for domestic use, recourse must be had chiefly to underground supplies. This necessitates pumping, and in the wind conditions of these very same Plains—in the relatively high and steady wind velocity—we have a source of power which is economical and reliable. Hence the windmill is one of the most characteristic features of the Great Plains. Far away in the distance, long before the farm buildings themselves can be seen, the tall steel frame, with its revolving wheel at the top, stands out against the distant sky line. We have here a curious and interesting climatic compensation, of inestimable money value to the farmers of our western Plains. In other parts of our country, also, where there is no constant necessity of irrigation, and where the winds, although less favorable as a source of power, are nevertheless reasonably well adapted for driving windmills much of the time, there should be an increasing use of this cheap and effective source of power for pumping water to be used temporarily in times of drought.

As illustrations of the work done by windmills, the following cases, reported by Dr. Frank Waldo, may be cited[18]. A wheel 12 feet in diameter raised 50,000-100,000 gallons of water a month to a height of 50 feet (Texas). A 10-foot wheel in Wisconsin raised 50 barrels of water daily to a height of 50 feet. A 10-foot wheel in Iowa raised enough water, to a height of 40 feet, to supply 300 head of cattle. In Missouri, a 16-foot wheel ground 20 bushels of corn in an hour. In Nebraska, a 10-foot wheel raised 1,000 gallons of water daily to a height of 70 feet.

So widely varying, under the influence of local topography, are the wind velocities over our western mountain and plateau region

("Plateau Province"), and so few and scattering are the available data, that lines of equal wind velocities cannot well be drawn for that section. The chart (Fig. 3) shows velocities varying from 5-6 to 10-12 miles an hour. It is to be expected that, in such a broken and mountainous topography, the velocities will, on the whole, be distinctly smaller than those on the Great Plains. The most sheltered localities are generally the least windy. Yet the use of windmills is by no means impossible in many parts of the Plateau Province, and the judicious choice of windmill sites where the conditions are most favorable would provide many localities with the means of irrigating.

In spite of its name, our Pacific coast ("Pacific Province"), at its northern exposed stations ("Northern Pacific"), has higher average wind velocities (16-22 miles an hour) than those at exposed points on the Atlantic coast. The conditions on these two coasts are, however, different, and cannot be directly compared. The higher velocities along the Pacific seaboard have been recorded on bluffs several hundred feet in elevation. South of San Francisco, light winds prevail ("Southern Pacific Province"), for storm control becomes less and less marked as we go southward along the coast.

Maximum Wind Velocities.—The most violent winds with which man has to contend in the United States are those of the tornado. The velocities—unrecorded because too great for any instrument to register—run up to 150, 200, possibly even to 300 miles an hour. Considering the size of the country, tornado blasts are relatively rare. They are in general limited to the "tornado belt" of the eastern United States, i. e., to the central and southern Mississippi Valley region, and from there, with decreasing frequency, to the States lying to the west and east. The sudden squall winds which accompany severe thunderstorms are responsible, next after tornadoes, for the highest winds of our interior districts. In many of our forests, often far from the beaten track of man's present-day wanderings, records of former tornadoes, and of other high winds, are preserved, decades after the occurrence of the blasts which uprooted and broke off the trees. "Fossil" tornadoes may be distinguished by the tangle and criss-crossing of the trees, which give the evidence of the tornado whirl. A straight "slash" through the forest, with the trees all prostrate in the same direction, is the "fossil" record of a straight-line gale or of a thundersquall.

West Indian hurricanes are responsible for the maximum wind velocities which are recorded along the south Atlantic and Gulf coasts, while severe winter storms bring the highest winds at the stations along the margin of the north Atlantic, north Pacific and Great Lakes.

For engineers and for architects it is important to know the absolute maximum of wind velocity which may occur in any district. But

for ordinary purposes, and as a matter of popular interest, a much more general indication of our highest wind velocities amply suffices. Excluding the relatively rare tornado, winds blowing for short periods at the rate of 50-75 miles an hour may occasionally be expected at interior stations, while velocities of 75 to 80 or 90 miles are not unlikely to occur in the most severe gales along our coasts. Our winter gales, and our summer and autumn hurricane winds along the Atlantic seaboard, too often bring danger and disaster to our shipping. The storm warnings of the Weather Bureau, indicating gales dangerous to navigation, are seen by our mariners with discouraging frequency.

In our western mountain regions the highest winds accompany the more severe winter storms, and have an important economic bearing in that they drift and pack the snow in the mountains, consolidating it for subsequent slow melting in spring and summer, and thus providing a more uniform and a more continuous supply of water for irrigation. Taking the country as a whole, the lowest wind velocities are found in the southwestern interior.

Exposed stations on the Pacific coast from San Francisco northward ("Northern Pacific Province") are subject, during the passage of severe winter storms, to gales with velocities running up to from 50 to 90, or even more, miles an hour. To the south ("Southern Pacific Province"), the maximum velocities are much lower, the highest winds blowing when winter storms move southward along the coast, or in connection with low-pressure areas over the interior (Sonora type). Point Reyes, Cal., a very exposed station, a little north of the Golden Gate, has recorded five-minute velocities of 110 miles an hour, and extreme velocities, in shorter periods, of 120 miles an hour[19]. The wind directions in these Pacific coast gales are southeasterly or northwesterly. Shipping is liable to suffer damage, but inland the loss, if any, is chiefly confined to the uprooting of standing timber. Occasionally, even in central and southern California, strong winds may damage standing crops.

Seasonal and Diurnal Variation in Wind Velocity.—With the annual progress of the seasons there comes a seasonal variation in our wind velocities. For the country as a whole, spring (March, April) is, in general, the windiest time of the year; middle and late summer (July, August), the calmest. March is proverbially a windy month. In the long run it deserves its reputation[20]. It is a transition month. The combined influence of the still active winter storm control and the rapidly-increasing diurnal (solar) control of summer makes for active wind movement. The difference between the average wind movement in the windiest and calmest months varies between 30% and 70% in different sections. The least difference is found over the Plains, the upper Lakes and the South Atlantic coast; the greatest, on

the north Pacific coast. It is a fact of notable economic importance that there is comparatively little seasonal difference in the wind velocities over the Great Plains. It is also economically important that the highest winds which sweep over the Plains are most common in winter and spring, when the contrasts in temperature are most marked, and not in summer. The damage to crops from this source is thus minimized.

The general increase in wind velocity from a minimum in the early morning to a maximum at 2 or 3 p. m. is a characteristic feature over most of the country, although there are exceptions, as on the Pacific coast. The change is most marked at inland stations, on clear days, and in summer, when storm control is least marked. Mr. P. C. Day has recently charted the average hourly wind velocities for the daylight hours (6 a. m. to 6 p. m.); for the approximate hour of maximum wind movement (3 p. m.), and for the approximate hour of least wind movement (6 a. m.)[21]. The daytime increase in wind velocity near the earth's surface over that of nighttime averages 20%-40%, and may reach 50% or more. The average daylight velocities approximate 10 miles or more an hour over much of the country. The Great Plains are conspicuous on account of their high velocities (over 12; over 16 in the Texas Panhandle), which are about the same as those at exposed points along the Atlantic coast and on the Great Lakes. Comparing the extreme day and night velocities (i. e., the average velocities at 6 a. m. and 3 p. m.), we find that the increase in the afternoon velocity over that of early morning is most marked in regions of light winds, as in protected valleys of the Rocky and Appalachian Mountains (75-100%). Over the Great Plains this increase is less (30-50%). The Plains, then, stand out conspicuously in their wind conditions. They have relatively high average wind velocities; there is little seasonal variation in velocity; and the winds of nighttime are relatively higher, as compared with those of daytime, than is the case over much of the country. All this makes the winds of the Great Plains an important and reliable source of power.

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36 charts fol. (These charts show (1) the average velocity of the wind at 65 representative stations at the hours ending at 8 A. M. and 8 P. M., 75th meridian time respectively; (2) the prevailing direction of the wind at a number of stations east of the Rocky Mts.; (3) the highest and lowest average hourly velocity of the wind, with the hour of occurrence; (4) the average number of times a velocity of 25 miles, or more, has been observed at the principal Lake stations.)

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MEMORIAL

Edward Van Dyke Robinson

Richard Elwood Dodge

In the sudden death of Edward Van Dyke Robinson, Professor of Economics in Columbia University, on December 10, 1915, this Association loses a valued member, who, in the full strength of mature training and experience, was contributing most efficiently to the development of economic geography.

Professor Robinson was born in Bloomington, Ill., on December 20, 1867, and graduated from the University of Michigan in 1890. After receiving the master's degree from the same institution in 1891, he completed his preliminary training in the University of Leipzig, which conferred on him a Doctor's degree in 1895. Returning to this country he took up high school teaching for twelve years. In 1907 he was called from the principalship of the St. Paul, Minnesota, high school to become Professor of Economics in the University of Minnesota. He held this position until he was called to Columbia University in 1915 to become Professor of Economics, in charge of undergraduate instruction in that subject.

Though an economist by training and experience, he early became interested in economic geography and contributed to the advancement of the subject both through his writing and his teaching. Professor Robinson was a natural teacher and won distinction in this field of labor, not merely because of his scholarship, but also because of his convincing enthusiasm and his real human interest in his students.

His most significant publications in economics are The Nature of the Federal State, 1893; War and Economics, 1900; Division of Government Power in Ancient Greece, 1901; Railroad Taxation in Minnesota, 1912; Cost of Government, National, State and Local, 1912. His Commercial Geography, 1909, was the first high school text in this field to give any adequate attention to the economic principles underlying commercial relations.

Professor Robinson's last contribution to geography was a memoir published only a few months before his death, entitled Early Economic Conditions and the Development of Agriculture in Minnesota, a model of what such a study should be.

Professor Robinson was an optimist who, by word and deed, contributed to the bettering of community conditions and civic life during his years at St. Paul and Minneapolis, a teacher who had won an enviable reputation by the strength and vigor of his work, and a man of winning personality, full of zeal and enthusiasm. His untimely death removes a master workman from the field of economics and geography.

TITLES AND ABSTRACTS OF PAPERS

Washington, 1915

Presidential Address—Richard E. Dodge.

Some Problems in Geographic Education, with Special Reference to Secondary Schools.—Printed in full herewith.

Henryk Arctowski.

A Possible Cause of the Pleionian Climatic Fluctuations.—Read by Title.

Oliver E. Baker.

A Map Showing the Agricultural, Forest, and Grazing Areas of the United States.—Read by Title.

The map described is to be included in the agricultural atlas of the United States, under preparation by the United States Department of Agriculture.

N. A. Bengston.

Outlines of Some Foreign Settlements in Nebraska.—Read by Title.

Nebraska was settled principally by people from Europe. The latter tended to form groups called settlements. The paper shows for a few of these the origin, development and changes in form. Many think of these settlements as solid groups. Careful mapping shows this to be somewhat in error. The foreign group presented considerable solidarity in the first generation. This, in some cases, tended to rapid development and sharply advancing prices of land. The waning of foreign solidarity in these settlements is marked and indicates some interesting changes now in progress.

Hiram Bingham.

Methods Followed in the Field Work of the Peruvian Expedition of Yale University and the National Geographic Society.

In organizing the Peruvian expeditions it has been the aim to include representatives of as many different sciences as possible. The field method has been to send a reconnaissance party to construct route maps, take many photographs, establish friendly relations with local officials, landowners and natives, and learn all possible regarding climatic conditions and the sources of food supply for the animals, the

last being particularly important in a country like Peru. This determines the character of future work. A topographic party is next sent into the field to make a map which will show roads, rivers, bridges, important peaks and other salient features, as desired by the parties that are to follow. Finally, armed with blue prints of the maps, with photographs and reports of previous parties, the trained specialist, be he geologist, zoologist, or archaeologist, can go immediately to work, and gain the best results. The speaker's work has been in historical geography, applied to two problems: (1) the identification of ancient place names referred to in the Peruvian chronicles of the sixteenth and seventeenth centuries, but not generally found on existing maps; and (2) the identification of newly-discovered ruins whose present names appear to be of recent origin and are not found in the chronicles.

William Bowie (Introduced).

The Place of Geodesy in Scientific Geography.

Geodesy is one of the important branches of geography and is essential in the determination of the shape and size of the earth, a knowledge of which is necessary in geographic research and investigations. From the data secured from geodetic observations we are enabled to determine approximate deviations from the normal in the densities in the outer portions of the earth. By means of triangulation and geodetic leveling the fundamental control in position and elevation is obtained for surveys and maps.

Albert Perry Brigham.

The Population of New York State.

The following topics were discussed: growth as compared with that of typical states in the South; the North-Central region and the West; center of population and its movement; population in relation to altitude, physiographic provinces, and drainage basins; urban and rural population; rural population as related to quality of soil and proximity of cities; belt of dense population as dependent on soil, climate, and facilities for transportation; capacity for population.

A Type of Geographical Description.

Various kinds of descriptions were noticed, as more or less geographical, such as those of the encyclopedia, the census, the guide book, the elementary text-book, the special treatise, accounts of exploration and survey, and the records and impressions of travel. Our modern geography should produce a type differing from all of these, mature in subject-matter, complete in its use of principles, finished in literary form, drawing from all sources, and suited not only to teachers and all other educated persons, but to the professional geographer who needs to know the unit considered, not in detail but in substance and total.

Alfred H. Brooks.

The Physiographic Provinces of Alaska.

Five principal physiographic provinces are recognized in Alaska, each one of which is divisible into a number of sub-provinces. These, named from south to north, are: the Pacific Mountain System, the Central Plateau Region, the Rocky Mountain System, the Arctic Mountain System, and the Arctic Slope Region. In this classification a new term, the Arctic Mountain System is introduced to include the mountain chain which traverses northern Alaska and parallels the Arctic Ocean. It was previously believed that it was an extension of the Canadian Rockies, but this interpretation has proved to be in error both from a tectonic and physiographic standpoint.

The Geography of Alaska in Its Relation to Man.

Geography has controlled the distribution and cultural development of the Alaska natives and, to a large extent, the approach to and occupation of the territory by the white man. This control has been exercised principally through geographic position, by character of relief, drainage, and shore line, by climate, and by distribution of animals and vegetation. The habits and distribution of the native population are the direct result of physical environment, due, in turn, to the interaction between various geographic factors. The distribution of animals and vegetation and the physical barriers to migration have been the controlling geographic influences on the natives of Alaska.

All of the geographic factors listed above have influenced to a greater or less extent the advance of the white man in Alaska. The first settlements in what is now Alaska were determined by the needs of the fur trade. Later, settlements were located to meet the needs of the fisheries, while in recent years a new factor has dominated. The distribution of mineral resources has largely determined the centers of population.

Robert M. Brown.

The Need of Considering Minimum Essentials in Geography. —Read by Title.

The paper presented the following points: brief outline of three or four proposals; statement of the demands of educational experts; call on the specialist to insist on a content of broad scope and to give thought to the possibilities of testing knowledge and ability in geography.

Collier Cobb.

Greek, Roman, and Arabian Survivals on the North Carolina Coast.—Read by Title.

Henry J. Cox.

Influence of the Great Lakes upon the Movement of High and Low-Pressure Areas.

The Great Lakes influence to a certain extent the movement of high and low-pressure areas which cross the North-Central states. Because of the higher temperature of the lake water in the colder months of the year as compared with the air temperature in the surrounding area there is a tendency for "highs" to avoid and "lows" to seek the lake route, and in the warmer months the converse is true. In the colder months there is a tendency for the pressure to decrease in "highs" and "lows" crossing the lakes, while in the warmer months the pressure tends to increase. "Highs" often develop over the lake region in the springtime and remain for a considerable period, thus insuring protracted fair weather.

W. M. Davis.

The Mission Range, Montana.

In recognition of the greater value in geographic description of the present than of a past tense, an account was given of what the Mission Range *is* rather than, as on the occasion of the Princeton meeting two years ago, of the processes of uplift, dissection, and glaciation, by which it *has been* formed.

Leon Dominian.

The Geographical Case of Turkey.—Read by Title.

Turkey occupies an eminently central position between highly developed and undeveloped areas. The country is the seat of the most convenient routes which link Europe to Asia or Africa. It is a link of the only direct land route which connects European centers of industry with populous markets of Asia.

By virtue of its position Turkey is the point of convergence of a great southeasterly drive of Teutonic peoples and the southeasterly expansion of Russians. It is the clashing ground of both. Through the Arabian peninsula at its southern end as well as through its alliance with the Germanic countries it forms a hostile wedge driven between the British sphere of influence in Egypt and the Indian Empire.

The survival of Asiatic influence represented by Turkish institutions on European soil is a direct result of the country's situation.

Charles R. Dryer.

Studies in Economic Geography. I. Definitions and Classifications. II. The Economic Regions of the United States.

I. A workable organization of economic geography was proposed, consisting of basic definitions and classifications of environments, economies, and economic societies.

II. On the basis provided in (I), the United States was divided into five natural economic regions, the leading environmental and economic factors of each region were discussed, and the rank among economic societies which appears to belong to each was assigned.

F. V. Emerson.

Geographic Factors and Cane Sugar.

The cultivation of sugar cane, a tropical plant, in the warm temperate climate of Louisiana and Texas presents some difficulties, and these conditions are reflected in the economic, sociological, and political life of the people.

Sugar cane ordinarily makes a good growth in Louisiana, but harvesting time is somewhat critical. A hard freeze before cutting will usually spoil the entire crop; the sugar content is altered by conditions of sunshine, temperature, relative humidity, and rainfall. Such climatic limitations render the industry somewhat precarious as compared with the great staples, cotton, corn, and wheat. The industry requires expensive, intensive cultivation during the growing season, rather quick gathering during the harvesting period, and fairly prompt sugar extraction during the "grinding season."

Several authropogeographic responses result from these conditions. The relative uncertainty of the crop, together with the extremely profitable yields in favorable years, attract venturesome *entrepreneurs* either possessed of, or, more frequently, able to borrow, considerable capital. Expensive cultivation and handling strongly tend to large scale management and to large plantations instead of moderate sized farms. This tendency is enhanced by the fact that it is a decided advantage to the planter in securing prompt treatment of his product to own or control his own manufacturing plant, and the tendency is therefore toward the control of plantations by capitalists or corporations. Hence it is that the large, somewhat self-sufficing plantation is rather characteristic of the sugar district.

Oliver L. Fassig.

A Simplified Form of Revolving Cloud Camera.—Read by Title.

The instrument is a greatly simplified form of revolving cloud camera, described in an article in the *Monthly Weather Review* for June, 1915. The camera takes in the entire dome of the sky, from horizon to zenith, at a single exposure of a second or less. The practical use of this camera in cloud topography has been demonstrated; its broader application in geographic, and especially military, exploration is considered in this paper.

James Walter Goldthwait.

Physiography of Cape Breton Island.—Read by Title.

The material for the paper was gathered during two seasons of

field work for the Geological Survey of Canada, in Nova Scotia and Cape Breton Island.

The physiographic divisions of Cape Breton Island are correlated with the upland and lowland divisions of Nova Scotia, described by Daly in 1902. The upland which dominates the landscape of Nova Scotia is found to extend across Cape Breton Island, appearing where hard crystalline rocks occur, in ten scattered belts of level-topped "hills" or "mountains," and rising northwestward to form an extensive tableland in Victoria and Inverness counties, 1,200 feet above the sea. The correlation of the several parts of this dismembered upland into one uplifted peneplain (thought to be of subaërial origin) is made clear by a comparison of their altitudes. The relation of the upland to the highlands of Nova Scotia, New Brunswick, and New Foundland is briefly considered, and the name "Atlantic Upland" proposed for the group. The intervening lowlands are attributed to subaërial denudation during the period which followed the elevation of the upland, carried to a point beyond maturity, wherever non-crystalline rocks of inferior strength occur.

The drainage systems retain but few traces of the original south-eastward-flowing consequent rivers, owing to widespread adjustments to transverse belts of weak rock during the later cycle. The effects of glaciation by the North American ice sheet, although distinct, are found only in smaller details of topography and of drainage, and in the dispersion of drift soils in two directions, by two successive movements. The shore-line, including the deep landlocked Bras D'Or Lakes, is complex, due to contrasts in rock structure, to the presence of several great fault escarpments, to glaciation, and to changes of level, which, however, do not appear to have been in progress since the occupation of the island.

J. Paul Goode.

The Geographic and Economic Foundations of the Great War. —Read by Title.

The influences which have led up to the Great War are found in the physical character of the countries, particularly the influence of the open plain, with its lack of natural boundaries; the distribution of race and language groups; the unequal distribution of natural resources, especially soil, coal and iron; the rise of modern industry and commerce, and the overflow into the outside world into colonies and spheres of influence; the rapid growth of urban manufacturing populations, and the resulting dependence for food upon outside lands. National rivalry and jealousy are expressed in land hunger and trade expansion; the climax of hatred is achieved between Britain, the ruler of the seas, and Germany, the most aggressive power on the continent.

Ellsworth Huntington.

Geographic Variables.

Every geographer recognizes that the effect of geographic environment varies. This variation has two aspects. In the first place man's own capacities vary greatly from region to region and in different stages of development. Therefore, a region such as the grassy prairies, which at one stage presents an insuperable obstacle to agriculture, may in a later stage become the region where agriculture is most profitable. The second type of variation is due to the fact that certain phases of geographic environment, especially the climatic conditions, change markedly from year to year and cycle to cycle. The work of Clayton on rainfall and panics; of Brückner on rainfall and migrations; of the British officials in India on famines, birth-rates, crime, and social conditions; of Moore on crops and economic cycles in the United States; and of Dexter on weather and conduct, are samples of an immense body of facts which belong to the realm of geographic variables. One of the next great steps in the science of geography is, perhaps, to correlate these facts, and to show how geographic variables, such as rainfall or other conditions of climate, give rise to a long series of constantly changing results, beginning with crops and annual migrations and going on to the prosperity of the farmers, fishermen, and others, the activity of merchants, the productivity of factories, the scale of general prices, the occurrence of financial panics, the amount of poverty and crime, and the play of all these conditions upon the world's political and social fabric. Such a treatment leads into the fields of biology on one side and of economics and history on the other, but geography can never occupy its rightful place without it.

Mark Jefferson.

The Plains of Europe.—Read by Title.

W. L. G. Joerg.

The Geographic Center: Its Definition and Determination. —Read by Title.

A general discussion of the problem of the "center of gravity" in its applicability to geographical phenomena. After a brief consideration of the three types, with examples, into which these phenomena may be divided (1, punctual: e. g., cities; 2, linear: e. g., railroads and other transportation systems; 3, areal: e. g., continents, countries, etc.) and the methods of determining their centers, the third type was examined in greater detail. Such topics as centers of areas (both of compact and divided areas, such as the mother country and colonial empires), the poles of the land and water hemispheres, centers of population and median points (Census Bureau) were discussed, as

well as the nuclei of phenomena represented by "isarithmals," such as contours and isobaths, isobars, isohyetals, lines of equal density of population. etc. The paper concluded with an estimate of the extent to which geographical centers may be used to express succinctly certain geographical relations.

Douglas W. Johnson.

The Strategic Value of Landforms in the Great Russian Retreat. —Read by Title.

The great Teutonic assault on the Russian line which began last spring had as its principal object the creation of salients in the Russian line, which would make possible the envelopment of considerable portions of the Russian army. Four dangerous salients were created, but in each instance the Teutonic plan was defeated by a skillful use of natural defensive lines by the Russians. In the same way the attempts by the Teutons to secure a satisfactory winter line on the east have thus far been frustrated.

Dora Keen (Introduced).

Avalanches as a Factor in the Alimentation of Glaciers.

C. F. Marbut.

The Relation of Soils to Crops in Southern California.

A soil map and a crop map, both worked out in detail, presented not only the geography of the various crops but also the relations of the various crops to the soils of the San Bernardino Valley.

The Dark-Colored Soils of the United States.

The work of Russian investigators on the dark-colored soils of Russia and Siberia has attracted a great deal of attention during the last few years. The character of these soils and the geographic conditions under which they have been developed were described briefly, and the dark-colored soils of the United States were compared with them in character, distribution, and origin. The agriculture on the dark-colored soils of the United States was briefly discussed by means of a comparison of a soil distribution map and agricultural maps.

F. E. Matthes.

The Post-Pleistocene Moraines of the Sierra Nevada.

Short but conspicuous moraine loops occur in front of all the small glaciers of the Sierra Nevada, as well as in a large number of empty cirques along the crest of the range. Their remarkably fresh appearance, in contrast with which even the younger members of the extensive Pleistocene moraine series seem subdued and ancient-looking, suggests strongly their deposition during post-Pleistocene and, in part at least,

historic times. Those last formed are comparable to the recent moraines of Switzerland and Savoy, which, through documentary evidence, have been identified as witnesses of moderate glacier pulsations that occurred during the eighteenth and nineteenth centuries.

The desirability at once suggests itself of a correlation of this record of post-Pleistocene climatic fluctuations with that contained in the rings of the Sequoias of the Sierra Nevada, on the one hand, and with that contained in the strand levels about Mono Lake and Owens Lake, on the other.

The conclusions are important in the study of glacial cirques, inasmuch as cirques containing such moraines must be considered as having been recently "renovated." They are not directly comparable to cirques that have been empty since the close of the last glacial epoch.

Alexander McAdie.

Geography and Aërography.—Read by Title.

Introduced the term Aërography or description of the atmosphere at all levels. In conformity with general use of the analogs Geography and Hydrography, would restrict the meaning of the term and differentiate from Aerology, a term used in the last four years for exploration in the upper or free air. The atmosphere is divided into two great divisions, the stratosphere and the troposphere. The work of two aërographers, Teisserenc de Bort and A. Lawrence Rotch, referred to. Examples of aerographical work are the volumes, "Charts of the Atmosphere for Aeronauts and Aviators," Rotch and Palmer, 1911, and the "Structure of the Atmosphere," by Cave, 1912. Various types of wind structure are referred to. The history of attempts to record and measure the flow of air is gone into from the time of the Tower of the Winds in Athens to modern determinations at various levels. The present instruments and methods of measuring winds are deemed defective and inadequate and the paper presented a plea for better units, newer methods and a wider appreciation of the great problem that bears directly upon human welfare and happiness.

Leonard O. Packard (Introduced).

Causes of Changes in Population along the Maine Coast.—Read by Title.

The distribution of population along the Maine coast is influenced greatly by the many indentations. Because of the advantages offered by the character of the shore-line itself and because of the natural resources, prosperous cities and towns developed.

Census reports show a marked falling off in the population of the coast towns for the past thirty years. This change is due to a decline in practically all of the industries which were responsible for the

earlier development of the region. The present condition is accounted for by a decrease in the advantages of water communication and by changes in the nature of the demands made by the industries which the region serves.

William G. Reed.

The Probability of Specified Meteorological Conditions.

A knowledge of the "business risk" from unfavorable weather conditions is essential for successful farming. The "probability curve" may be used to determine this risk. As an illustration of what may be done a map of the dates after which killing frost will occur only one year in ten on the average was shown. Similar maps have been made for autumn frosts and for the probable season without killing frost four years in five.

John L. Rich (Introduced).

Correlation of Cultural Features with Stage in the Erosion Cycle.

Since cultural features—as roads, houses, clearings, villages, and cities—are the outward expression of the life of the people, their control by natural conditions such as relief, slope, or climate may be taken as a partial measure of the influences which the latter exert upon the activities of the people of the region under investigation. Quantitative measurements of the distribution of three cultural features—roads, houses, and towns—were made for typical examples of topography in each stage of the erosion cycle and their results expressed in percentages and correlated by means of graphs. In infancy and youth *upland culture* predominates; clearings, roads, houses, and towns are on the uplands while the valleys are avoided. With advance toward early maturity, culture descends more and more into the valleys until in early maturity, *valley culture* prevails. With advance toward late maturity and old age *slope culture* begins to dominate and increases progressively until in the final stage, peneplanation, *universal culture* is inaugurated.

G. B. Roorbach.

Venezuelan Trade and the War in Europe.—Read by Title.

Howard E. Simpson (Introduced).

The Islands of Devils Lake, North Dakota, and Their Significance.

A sketch of the origin and life history of the ice-built boulder piles in a rapidly disappearing glacial lake, with the additional evidence which they offer of the pulsatory climatic changes which have taken place in the Northwest since the close of the Glacial Period.

H. L. Shantz (Introduced).

Correlation of Natural Vegetation, Soil Type, and Early Settlement in Eastern Colorado.

The principal plant associations of eastern Colorado, the relation of these associations to soil type, and the relation of vegetation type and soil type to grazing and crop production. The distribution of the plant associations was shown by sketch maps.

Philip S. Smith.

Notes on the Exploration of Lake Clark-Icitarod Region, Alaska.

The region extends from the western flanks of the Pacific Mountains well in to the Central Plateau Province of Alaska. A narrative account of the expedition and a general summary of the topographic features, climate, vegetation, settlements, and population were given.

J. Russell Smith.

The Island and the Continent at War.

The conflict between England and Germany was traced in part to contrasting geographical conditions. The continental location of Germany, exposing her to invasion on nearly every side, naturally developed fear of her neighbors and this, in turn, bred a respect in her people for any kind of authority that could protect them. Hence their obedience to military organization and individual subordination.

England, on the other hand, has been free from any danger without, because of her insularity and her fleet. This has led to greater political and individual freedom, but also to a greater laxity of organization, as evidenced by internal political dissensions and the relative neglect of education and science.

Walter S. Tower.

A Geographic Comparison of Vancouver and Prince Rupert, B. C. —Read by Title.

The old and new Pacific outlets for Western Canada; topographic influences affecting the two ports; the tributary areas, their industries and undeveloped resources; lines of transportation between coast and interior; relations to ocean routes and foreign markets; relative advantages of each port.

T. Wayland Vaughan.

Some Physiographic Features of the Cuban Shore-Line and Their Bearing on Strand-Line Oscillation.—Read by Title.

Robert DeC. Ward.

The Prevailing Winds of the United States.—Printed in full herewith.

R. H. Whitbeck.

Geographic Environment as a Factor in Evolution and in Race Differentiation.

The influence of geographic environment is one of the basic questions of scientific geography. At the bottom, it is a biological question,—Can environment so act upon organisms as progressively to modify them and eventually produce wide variations from the parent stock? If so, how is it accomplished? Are differences in environment, and are changes in environmental conditions competent to bring about the present differentiations among groups of plants, animals, and men?

One Urgent Need in the Field of Educational Geography.

A nation-wide agitation in favor of making General Science the introductory science of the high school is now going on. This movement, which means a widespread displacing of Physical Geography, has gained strong headway; geographers have thus far manifested little disposition to support the claims of their science. This may be due to their willingness to see Physical Geography give place to humanized geography, but many school principals and superintendents do not know that there is any movement toward humanized geography and are dropping physical geography from the curriculum. In the educational magazines, articles which would inform school men on matters dealing with educational geography, rarely appear. There is urgent need that geographers contribute to general educational magazines articles which will remedy this situation.

INDEX

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CONTENTS

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SOME CONSIDERATIONS ON THE GEOGRAPHICAL PROVINCES OF THE UNITED STATES*

MARK JEFFERSON

CONTENTS

Introduction: Man's Relation to the Earth.—Our constitution allows us many aspects of geography. We have room in our membership for cartographers, a terrestrial magnetician, zoologists, botanists, geologists, physiographers, historians and travelers, yet very generally we have especial interest in those aspects of the science that concern themselves with man. We want to find applications to man for what we learn about the earth, almost above all other things.

Geographic Influences.—Man's relations to the earth are of three main sorts. First he has been guided in his migrations by the configuration of lands and seas and the relief of the earth's surface—the geographic influences in history to which some of our members have made important contributions. Perhaps it is the field of human geography that has been cultivated most profitably.

* Presidential Address delivered before the Association of American Geographers, New York Meeting, December, 1916.

Anthropogeography.—A second sort of human geography is usually called anthropogeography. It attempts to explain the character and habits of a people by their environment. This field has special perils. A great part of what has been written is vague and fanciful rather than cautious and well-based. If no other explanation of qualities is available one may always refer to the "climate."

Anthropography.—The third field has been less cultivated, but is fundamental. It studies the distribution of men over the earth as a static fact, regardless of their movements or occupation, but paying much attention to the closeness with which they occupy their region, or the density of population from place to place. The full topical name, *distribution of population-densities*, is somewhat cumbrous. As an arbitrary name *Anthropography* would have some advantages, and its etymology is quite as good as that of many accepted names. So defined, it would be primarily a descriptive science. The questions, Where are men and How many of them are there must be answered with some care before we attempt to explain the reactions of men and inanimate nature.

Population Density Maps.—*The Data.*—The data of this aspect of geography are contained or represented on the map of population densities. There is as yet no satisfactory one for the world. Those that exist are very small of scale, rarely larger than 1:80,000,000. Even on that scale they do not show good agreement. If we had a satisfactory one on a scale, say, of 1:5,000,000, it is certain that we could at once see on it the influences of rainfall, geology, physiography, and possibly temperature, as they are shown on maps already extant, with their information in considerable detail. If all these forms of environment react on man it is evident that the facts of man's distribution among them should be known in all possible detail before we study the reactions. Yet it is curious that less attention has been paid to the facts of anthropography than to the causes that ought to guide and control them. The geographic provinces of this viewpoint would be the actual groupings of men on the earth quite irrespective of any climatic or physiographic boundaries that should hypothetically control them. As a matter of fact such a study of actualities shows that some of the supposed climatic and physiographic controls are of less importance than was supposed.

Population and Precipitation in India.—As an instance may be cited the ten-millionth population map of India made by the Indian Census (1911). Comparison with the precipitation map, also made by the government of India, shows that the largest masses of very dense population do not live where the rains are heaviest, as is often supposed, but mostly in level regions of moderate or even scanty rainfall that lie under mountain slopes where the rains are heavy. It is

the irrigation of level land that supports these swarms of men, rather than heavy rainfall.

This touches what appears to be an important law in the distribution of men, that roughly level expanses of soil are almost more important for a great population than rainfall.[1]

Difficulties with Current Methods of Mapping.—But there is no agreement as to how population maps should be made. A great practical difficulty in representing the actual density of population from place to place is the very great range through which the density changes in short distances. Within twenty miles in New York we may find men living thirty to the square mile and again six hundred thousand to the mile. How shall we represent differences so extraordinary?

Cities, towns, villages, and farms seem so different as to require different treatment. It has often been the practice, therefore, in making population-density maps, to subtract the city population from the totals, with the idea that the rural inhabitants are the real occupants and users of the earth. The population maps of the United States Census have been made in this way, at least in theory. In practice, one has to have a definition of a city before he can leave it out. So far our Census bureau has had three different definitions: that cities were incorporated places whose inhabitants numbered 8,000 (definition of 1870), 4,000 (definition of 1900), and 2,500 (definition of 1910); and these appear to be rather violent and arbitrary changes of concept.

Another practical difficulty with population maps is the necessity of assuming an even distribution of the population over the whole surface of the smallest units of area for which we have data. In the United States, for instance, we divide the population of a county by its area in square miles, and pretend that the whole county has the density so ascertained. As long as the county is very small indeed in comparison with the whole map, as a Massachusetts county would be on a map of the whole United States, this serves excellently. With the counties of Utah it is less acceptable, for some of them are immense and extend from the full desert into the well-watered lands where the people actually dwell. To spread the population over the whole area is arbitrarily to increase the population in the desert and diminish it in the watered lands. Sometimes population is represented by dots, each dot standing for 1,000 or 10,000 people. But this involves putting the dots in something like correct places and with the large administrative units, like the basin of the Amazon, no one knows quite where they should go. Of course the details of boundaries between grades of population that follow county boundaries have no anthropographic meaning.

[1] Census of India, 1911, Vol. I, Pt. I, p. 18.

THE UNITY OF CITY AND COUNTRY.—But a rather extended investigation of cities and their relation to the land shows the essential unity of city and country. It is a wholly mistaken conception that attempts to separate them. Any group of close-living people who are mainly occupied with the exchange and elaboration of products rather than their direct production from the earth, whether it be a few houses at a cross-roads, a village, a town, a city or a metropolis, is a center of human activities that involve areas far beyond the immediate neighborhood. Such a group is larger or smaller according as the activities of more or fewer men are focused there. Wherever men occupy a land and go to work upon it, there appear villages and towns and cities. I am speaking of the civilized men of the world of to-day. Civilization means community life. The village and city workers are engaged in tasks that aid and prosper life in the country. Governmental functions center there and all sorts of services of agents with delegated powers, but the work is for city and country people alike. The plowing of country furrows, the reaping of country crops, the milking of country cows is of vital interest to the great city, motivated by events that happen within the city. The city is the creature of the country and cannot live without it. The city-dweller knows that without the country he would have no place from which to buy his food. He is not so well aware that without the country he would have no money to buy it with.

A great country population cannot exist to-day among civilized men without bringing cities into existence. Neither Norway nor Ecuador, on the other hand, can have a great city because they have no great country population.

THE IMPORTANCE OF A STRATEGIC POSITION FOR A CITY.—No city becomes a great one nowadays, unless it has a strategic position. All cities are groups of men, in last analysis. Travel and communication have become very easy, and men in every town and city are eagerly competing for the generous rewards of modern business. Any real advantage of position of one town over another must finally bring business that way. Men do not know clearly what position is going to prove strategic, do not always recognize what the advantage of a growing town really is, but the greater growth of one city than of others around it is evidence of some geographic advantage. That city has proved that it stands in a good position to render service to its community. Geographic environment is the main determinant of size. A city of a million inhabitants must have access to a wide countryside. Thanks to modern shipping a city may now make distant lands its countryside. London is the great city not merely of England and of Great Britain, but also of the British Empire and of a good bit of the rest of the world. It has reached

out successively over the London basin, over Britain, the Empire and the world for its sustenance space.

The Numerical Relation Between the Number of Cities and the Mass of the Population.—There is a numerical relation between the number of cities and the mass of the population. The world contains about 355 cities of more than a hundred thousand people. We will call cities of that size Great Cities. There is one of them, then, for every five million people. But the thing is not so simple as that. We have implied as much when we said that cities were foci of human activity. Some men are very active and some do not react at all to the stimuli of civilization. Africa's seven great cities amount to one for every twenty-one million people. But many of the people of Africa are in no sort of touch with any of these cities. They are not the sort of people to create or use cities of that size. People need more and more great cities in proportion as they have higher status in the modern scheme of culture. If we reckon the relative number of great cities to each ten million people in different countries, we should have: in Australia 12, in the United Kingdom 9, in Switzerland 8, in Canada 7, in the United States 7, in Holland 7, in Germany 7, and then, after a long list of intermediate countries, in Japan 2 and in India 1. Further if we class cities of from ten to a hundred thousand as small ones we find for each ten million people: in England 123, in the United States 53, in Canada 53, and in India 37.

For the different parts of the United States the number varies from 5 for the South and Mid-west to 11 for the Northeast and 12 for the Pacific coast.

The Degree of Man's Occupation of the Earth as Evidenced by the Number and Size of Cities.—On account of the special character of cities as foci of human activities, it will be of interest to reverse the procedure of the Census and, instead of omitting the cities, omit the country and use the cities and their size as a criterion of the degree of man's occupation of the earth. They have the great advantage for this purpose in that they may be precisely located. If we could make a great map of the world that would show in their correct location not merely the great cities, but the small ones and the little towns and villages, with some connotation of the number of people in each that could be read at a glance, without any names to confuse the effects, we should have the best representation of the actual distribution of men over the earth. The groupings of these human foci would sketch for us the actual geographic provinces of the earth, not physiographic, not geologic, not climatic nor yet political, but geographic as showing man on the actual earth in the play of varied forces.

Not only have such maps not been made, but the best maps available

mask the information they contain in various ways, so that it is as difficult to get as if intentionally concealed. Most of the data needed for such maps exist in civilized countries. Even in lands of less culture a fair approximation is possible. The value of such a map, however, has not been recognized.

As a step toward it I offer here maps of all the cities of ten thousand inhabitants or more in agricultural India, in the industrial United Kingdom, and in the United States, in nineteen graded symbols suggesting size by their own magnitude and giving some detail by their shape (Pl. II). All three maps are for the year 1910 (United Kingdom 1911); all are on the same scale of 1:15,000,000, which is seen to be pretty small even with our omission of the smaller places.

The Cities Map of the United Kingdom.—Of the British map, another impression is added on a larger scale, 1:4,300,000,[2] inasmuch as the symbols are not legible on the smaller scale. The smaller map, however, affords the proper basis for areal comparison and at least gives mass effects. The maps of India, the United States, and the United Kingdom on the same scale give at a glance an impression of the populousness of the three regions, as far as is possible with the omission of the smaller places, a much greater omission for India than for the western countries.

The Five Geographic Provinces of the British Islands.—These British towns, 542 in number, fall into five groups, which may be said to constitute, from a human point of view, the five geographic provinces of the British Islands. The groups are: the Scottish lowlands, the Newcastle coalfields, the Midlands, the South Wales coalfields, and the London basin. It is impossible to look at this map, knowing the position of the coalfields of the United Kingdom, and escape the conviction that coal is dominant in British geography.[3] Only the London basin was determined by other factors. Yet that is the great center of the kingdom and the empire. Plainly commerce avails more than coal, but it has reacted on it. It is a commerce that has been built up on the coalfield industries; and it is directed especially towards the continent of Europe. That is what its location about London signifies.

These are the five geographic provinces of the United Kingdom. They are very real. Though some of them do not appear in our geographies, they are constantly in the mouths of British men of business. They are wonderfully illuminated by a map of British coalfields. A relief map sheds sidelight by showing that Britain's

[2] Practically the same as the scale of the map in its original published form in the *Geographical Review* for Nov., 1917, and the writer's *Notes on the Geography of Europe*, Ypsilanti, Mich., 1917.

[3] Mark Jefferson: The Distribution of British Cities and the Empire. *Geogr. Rev.*, Vol. 4, 1917, pp. 387-394.

rough, mountainous country has no cities, even small ones. It appears that the only physiographic feature that attracts men in the mass is the plain. The geologic map will contribute details in the lowlands. We are interested in the vividness with which this map portrays a country according to geographic regions.

The Cities Map of India.—On the map of India the cities are shown by the same method. India is an interesting country to examine in this way because the people are regarded as averse to city life. This does not mean however that the Indians live in isolated homes, but that villages rather than cities are the foci of Indian life. A peculiar feature of the great cities of India, which may be indicative of their abnormality in Indian life, is the fact that women form so small a part of their populations. In Calcutta there are but 480 women to a thousand men, in Bombay but 530. The explanation is that large numbers of men come into these cities for factory work and leave their women outside, in country villages. Nevertheless India has 33 large cities and over 600 small ones, as defined above.

The Six Groups of Indian Cities.—Again we see the cities falling into groups, of which the most striking is that of the Indo-Gangetic plain, that sweeps from the Ganges' mouth to the sources of the Indus. We may call it sub-Himalayan. It is the greatest group of people in India. The country is extremely level. It has 40 to 60 inches of rain in the eastern half, but the west has only 10 to 20, or even less. Here irrigation is possible from the well-watered slopes of the Himalayas above. "Throughout India the most thickly peopled tracts are level plains, where practically every inch of the land is fit for tillage."[4]

A second group is in Madras in the south and east, another district of very level land, in some places not well supplied with rain. The third group is Central India, including the region locally known as the Deccan. On the east it is separated from Madras by hilly country, too rough for agriculture, though it has plenty of rain. On the west it is bordered by the still rougher region of the western Ghats, which stands out on the rain map as a strip of excessive rainfall, on the city map as quite without cities.

A fourth group lies along the level plains at the foot of the western Ghats. Population maps here are misleading. As they have to bound the province by a *line,* and put it somewhere among the rougher crests, the population appears to be evenly spread from the sea into the mountains. The human boundary is not a line at all but the whole mountain region. This appears on the city map separating the cities of the coast plain from those of Central India. This region may be called the Malabar coast.

[4] Census of India, 1911, Vol. I, Pt. I, p. 27.

Fifth is the Gujarat group on the remarkable levels northwest of Bombay.

Sixth and last is the two-fold province Burma. It is a region of very rapid expansion. In the middle of the last century the population here had been nearly exterminated by tribal wars. It is probable therefore that it will grow beyond its present boundaries. In large part it is an island of lighter rainfall with excessive rains all around.

It is characteristic of the human point of view that province boundaries are regions rather than lines. Even a country is not to be regarded as a portion of the earth's surface between bounding lines but a group of people under one government together with the portion of the earth that they have in actual use. The portions of the earth not well in use constitute territories that belong to a country rather than a part of the country. Alaska is not so much a part of the United States as a territory that belongs to it. The historic conception of territories and their transformation into states of our Union confirms this view. The general basis of the transformation of territories into states is the extent to which the state is settled, as indicated by the number of its people. It is unused territory within a country that constitutes the boundaries of geographic provinces. Such are the Pennines and the Yorkshire Wolds in England, the Ghats in India, the Sierras in America, and all deserts everywhere.

The Cities Map of the United States.—The map of the United States on Plate II is the equivalent of the maps of the United Kingdom and of India, on the same scale and plan. It gives the same picture of man occupying the earth. The groupings of men under reaction to their environment come out at once as before. As geography transcends political boundaries, Canada is included. Nothing on the map, indeed, is more striking than the way portions of Canada unite with neighboring portions of the United States.

But in the case of the United States we are able to go farther in mapping man's occupation of the earth and include all incorporated places that have a population of over a thousand people.

Plate I shows the result, on a much larger scale (1:5,000,000), than the first three maps to allow the greater detail.

The Continental Provinces.—Three great continental provinces appear: the humid east, the arid interior, and the Pacific coast valleys.

(Footnote: In New England villages are not incorporated apart from the country district around. There we have only the population numbers for the entire township, which is always somewhat larger than the population of the village center. So the smaller places of New England are a little too large and too numerous. But this does not alter any essential feature of the map.)

The humid east is bounded on the north by the amazingly empty Archaean V in Canada, on the west by the dry high plains along the hundredth meridian.

The arid interior is bounded on the east by the dry plains, on the west by the basin deserts and the mountain country of Sierra Nevada and Cascades.

The Humid East: Subdivisions.—Subdivisions of the humid east are suggested by the very great concentration of cities along the Atlantic inner-lowland, by the close, even spacing of the cities of the mid-west, and the open, less even spacing of the cities further south. These subdivisions may be called the northeast, the mid-west, and the south. The first would correspond in a general way to the New England states and the middle Atlantic states of the Census bureau, the second to the east north-central and west north-central states of the Census and the third to the south Atlantic, the east south-central and the west south-central states. But if these provinces were used for statistical purposes, which require the use of *lines* for boundaries, the lines should not be drawn along the state boundaries, for in places one state lies in two provinces. Northern Kentucky and West Virginia belong to the mid-west rather than to the south, and most of Maryland belongs to the northeast. If administrative lines were needed in those places they should be county lines rather than state lines. So in the west. As the dry plains form the western border of the humid east, it includes only the eastern parts of the Dakotas, Nebraska, Kansas, Oklahoma, and Texas. Eastern Kansas is in the same geographic province as Missouri, western Kansas in the same one with eastern Colorado. Similarly in the far west, Okanagan, Chelan, Kititas, Yakima, and Klikitat counties in eastern Washington belong to the arid interior. The rest of the state belongs to the Pacific coast valleys, like all of Oregon except Wasco, Crook, and Klamath counties. The geographic duality of these two states is too evident to escape anyone, and economic reports should be given separately for the two sections. The boundary of the humid east on the north, against the Archaean V, is on Canadian ground, but it invades the United States again in the Adirondacks of New York and the rough country of northern Michigan and Wisconsin. This adds the eastern Canadians and their land to the humid east, regardless of politics.

The Pacific Coast Valleys.—The title Pacific coast valleys rather than states is given because the cities are so obviously valley cities. Moreover the people who live there refer to the valleys constantly. The valleys characterize the relief of the western border of America from Cape Horn to Alaska. The coast ranges, quite unlike the Appalachians, are strongly deterrent to men. The cities of the coast suggest three subdivisions. The northern one would include the Puget

Sound valley, the Willamette valley and the Rogue river country; the central one, the great valley of central California and some near coast valleys; the southern one, the Los Angeles basin, the group of irrigated settlements of southern California, containing perhaps a twentieth of the area of the state. The grouping of the cities makes this region very distinct, and it appears equally so physiographically, climatically and economically.

The Arid Interior.—In the arid interior the feature is the openness of the distribution. But there are three centers of concentration: the Colorado region extending north and south from Denver at the eastern foot of the Front Range of the Rockies; the Utah region, lying along the western foot of the Wasatch; and the Columbia-Snake river basin—it hardly seems a plateau,—lying in a great saucerlike hollow among bounding mountains. Though in three states, Washington, Idaho, and Oregon, it appears to be a distinct unit. As so often in the far west the physiography confirms the subdivision.

Summaries.—The insignificance of the Appalachians in controlling human occupation of the ground is as surprising as the sharpness of control in the west. Cities are closer together in eastern Tennessee and Kentucky than in some western parts of the same states. The empty mountain region along the boundary between West Virginia and Virginia is hardly larger than the area in central Virginia between the mountains and Richmond. Within Virginia the Shenandoah valley is a more important feature than the Appalachian ridges, and is well sprinkled with towns. Nor is western North Carolina, where occur the highest mountains east of the Mississippi, so empty of towns as the singular strip along the western border of Alabama, where there are no mountains. Always it is the valley and not the mountain that concerns men.

The greatest concentration of cities in the whole continent lies along the Atlantic inner-lowland, well apart from the mountains but humanly the most distinct region of the whole continent. The cities suggest that we continue it from beyond Washington, D. C., to Boston. No contrast on the map is so striking as that between this inner lowland and northern Maine, New Brunswick and Nova Scotia. Whatever resources geography may possess to explain the differences in man's use of New Brunswick and southern New England, the cities map brings the differences sharply before us. It will do this indeed in almost every part of the country.

The City Map of Florida.—How is it so little of the significance of city positions is shown on actual maps? It is largely due to the map-makers' abhorrence of vacant spaces. In Florida, for instance,

our city map shows the people living mainly on what Harper has called the loamy and sandy uplands of the central and northern parts of the state. The 40-mile-to-an-inch contour map of the United States in contours by the United States Geological Survey (1914) does not give the slightest impression of the human facts of the state, not even the emptiness of southern Florida. It is not an especially bad map but it is physiographic in its conception and cares not for geography. It will be worth while to look at it a little in detail. Florida has 52 incorporated places of a thousand or more people. The Survey map shows 68 places in all, but 18 of the 52 are not shown. It has therefore added 34 places of less than a thousand people and omitted 18 of more than a thousand! Some of the omitted places are of significant size: West Tampa has 8,000 people, St. Petersburg over 4,000, Lakeland and Sanford nearly 4,000, two others over 2,000, and the rest between 1,000 and 2,000. Why a third of the larger towns were omitted when twice as many smaller ones were inserted is not in all cases clear. South Jacksonville, New Augustine, and West Tampa may have been regarded as suburbs of the larger towns which it would confuse the lettering to include. Two or three towns would be hard to letter in on account of the railroads near by. Sometimes, as with Hillsboro county (now subdivided—1914—into Hillsboro and Pinella counties), it would appear that the draughtsman did not finish his work, for he put in only Tampa and Clearwater, omitting West Tampa 8,258, St. Petersburg 4,127, Plant City 2,481, Tarpon Springs 2,212, and Port Tampa, 1,343. There is plenty of room on the map for these towns. Apparently they were simply overlooked. But doubtless no numerical criterion was in the map compiler's mind and he had no list of populations before him. A third (13) of the small places inserted are county seats, which are usually regarded as of special importance. There remain 21 places small and unexplained. In De Soto county Wauchula and Punta Gorda, both above 1,000, were omitted, and there were inserted three small ones; Fort Ogden 483, Boca Grande 281 and Pine Level 262. There was plenty of room on the map here and the selection of names made adds nothing to the evenness with which names are put in on the map. In Polk county were omitted Ft. Meade 1,165, Mulberry 1,418, and Lakeland 3,719. Perhaps the most interesting of the little places added is Enterprise in Volusia county. It is a voting precinct, not incorporated. It had 590 inhabitants in 1890, dwindled to 284 in 1900 and to 188 in 1910. Probably Enterprise had some importance in 1890. There were at that date but 28 incorporated places in Florida larger than it. To-day there are hundreds of places more important. It is on the map as a survival.

Selecting Cities by Principle in Map-Making.—If the scale of a map does not allow the insertion of all places, a selection should be made governed by some principle. The draughtsman must be forbidden to even up the lettering by putting in all the places where places are scarce and omitting some where they are crowded.

Enough has been said to show the desirability of preparing place names for a map with some care and having some criterion by which to select them. None will be found so objective and so useful as the criterion of size.

It has been said that a place of 500 people in Arizona is more important than one of 5,000 in Massachusetts. It may be more important to the people within twenty miles. It is more important in its own locality, but on a map of the whole United States it is not more important. It does not stand for so much American doing and living as the Massachusetts town. In comparative views for wide areas the criterion of size is the only safe one. It is a fundamental fact in the geography of Arizona that a handful of human beings occupy it; of Massachusetts that great numbers of people live there and work there.

The "relief map" of the United States Geological Survey (1911) prints 13 place names in Arizona and 11 in Massachusetts. That is as if we were to insert all places of over 2,000 people in Arizona and all of more than 40,000 in Massachusetts. It is true that if only places of 40,000 or more were represented, Arizona would have none, nor would New Mexico, Nevada, Wyoming or Idaho. It is true that the people of these states would not like to see them without towns on a national map and that each of them has as many senators as Massachusetts or New York, that there is plenty of room to insert place names in the west, and that this is "only" a relief map. But once attention is called to it the selection of place names on this map is seen to be not well considered, and it is an excellent example of the way current maps utterly misrepresent human activities on the earth.

The only maps that give adequate expression to the location of cities and villages to-day are the large wall maps of states, such as Silas Farmer's wall map of Michigan. The Land Office map of Florida also brings out well the location of occupation, in spite of much bright coloring that confuses.

Positive and Negative Physiographic Types.—It has been noted how strongly actual geography discriminates between physiographic types. It regards them indeed as positive and negative. The positive types are plains, basins, or valleys where men make their homes if the rainfall or irrigation permits. The negative types are rugged mountain masses where men may not live in any general occupation of the surface. Such landscapes can never be geographic provinces, but

only boundary regions between geographic provinces. Thus in Fenneman's admirable Physiographic Divisions of the United States,[5] no. 22, the Sierra Nevada-Cascade province is geographically negative, a boundary region between the basins on the east and the valleys on the west. That is a good example of the divergence of physiographic and geographic conceptions. The physiographer's country is made of rock and dirt in varied moldings, interspersed with water. The geographer's country is a group of men living on and from the earth. The negative provinces of the physiographer are best treated by the geographer as *territory* belonging to some near country. Outside of school rooms this is universal usage. The Australian you met yesterday comes from the inhabited coastal fringe where the Australians live. If some mischance dropped him in the interior of what the school room knows as Australia, he knows he would be in the Australian desert, in Australian territory, of course, but in great danger of never reaching his home alive. The Canadian you meet to-morrow will not be a man born in the territories west of Hudson Bay, there is not one chance in millions of it, but from the St. Lawrence valley, or the southeastern coast region, probably. For political purposes boundaries must be lines, that the areas of legal jurisdiction may be defined. Humanly the boundaries are oftener regions, like the Sahara, or the southern Andes, which stand, not partly in Chile and partly in the Argentine Republic, but *between* Chile and the Argentine Republic. Indeed the linear character even of legal boundaries in mountain regions is largely theoretical. The Argentine law officers are entitled to make arrests east of the Cumbre in the Mendoza pass, and the Chileans west of it; but in fact the criminal is practically safe as soon as he enters the mountains in either country, so difficult is pursuit and discovery there.

THE LIMITATIONS IN THE USE OF PHYSIOGRAPHIC PROVINCES.—It is for this reason that physiographic provinces are unsuitable for human, statistical use, as in reporting the results of a census. There is little interest in the number of inhabitants of the Sierra Nevada-Cascade province, or in its production of wheat or apples. It could hardly show a significant product other than minerals and is unnecessarily complex for even a map of mineral products. But there is an enormous interest in the number of people in the Pacific coast valleys, and their production of grain and fruit. To report census data by physiographic provinces will serve no other purpose than to show how unsuitable these provinces are for the representation of human activities.

Geography is not to be regarded in its human aspects as the story of Earth and Man, but as the study of Man using and living on the Earth.

[5] *Annals Assoc. Amer. Geogr.*, Vol. VI, 1916, pp. 19-98.

Annals of the Association of American Geographers
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SRIHARIKOTA AND THE YANADIS

A Sandy Island Off the East Coast of India and its Inhabitants

SUMNER W. CUSHING

CONTENTS

Introduction.—*Acknowledgments.*—In the way of introducing this paper I wish to acknowledge my indebtedness to Professor W. M. Davis and Harvard University for opportunity to visit the Orient and carry on the study outlined in this paper, and numerous other geographical studies.

The Organization of Responses to Geographical Environments.—To search out responses to geographical environments is often a task of great difficulty not only because environments are so complex but also because man responds differently to them at different stages of development. As the science of geography advances it may in time be possible to perfect an organization of its subject matter around three centers—land forms, climate, and stages of culture. It may be possible, for instance, to classify the influences which a young mountain mass located in the subtropical belt exerts upon a primitive people or upon a highly civilized people; or to classify the influence exerted by the same kind of mountains located in the subequatorial belt upon a primitive people. Investigations might in time reveal responses that primitive and advanced people give to every type of land form at various stages of dissection located within the different climatic belts.

This paper may be regarded as a first short step into such a scheme of systematic geography, since it deals with an island off a young coastal plain. The island is probably the simplest part of the simplest type of land form. Moreover, its inhabitants, simple jungle folk, are in the most elemental stage of evolution. The island has the monsoon type of climate.

The Setting and Physical Conditions of Srīharikota.—The Coromandel or the East Coast of India presents to the Bay of Bengal a

shoreline backed, except in a few places, with a monotonously low relief. If one braves the tumultuous shallow inshore waters of the bay from Calcutta to Cape Comorin his typical view is of a silver strand surmounted by jungle growth. Occasionally a light house, or a group of houses with a pier in front of them, takes the attention. Only once is the imagination stirred with the evidence of noticeable commercial activities and of the existence of an important center of population. That is while opposite Madras.

But the monotony of conditions suggested by the view from a boat is not borne out when one visits the people who inhabit the land that skirts the shore. Here one finds a broad fertile delta densely inhabited by a relatively progressive people who live by agriculture. There one comes to an infertile island that is occupied by a primitive jungle tribe. Again one follows for scores of miles a low sandy plain whose people take an intermediate rank in cultural development.

The variety of land forms found along the Coromandel is typical of the outer margin of a young coastal plain. Where large rivers pour their waters into the shallows of the bay broad deltas are built forward. Where the strong waves driven forward by the north east trades have agitated the sands of the bay bottom and piled them up above sea level there is likely to be a sand reef. Often these reefs are separated from the mainland by a lagoon or marsh. Most of the sand reefs along the east coast of India have been connected with the mainland by the filling with sediment of the lagoons that formerly backed them. The marshes thus formed are readily crossed except at the time of high river floods or unusually high tides. This paper treats of Srīharikota, the largest of the sandy reefs or islands that are still isolated from the mainland, and the Yānādis, the people who occupy it.

Srīharikota is located forty-five miles north of Madras and is separated from the mainland by a large lagoon called Pulicat Lake. The island stretches thirty-five miles from south to north and broadens to six miles toward the north. The soil is everywhere sandy and the relief is made up of sand plains, fixed dunes, blowout basins, and, on the lagoon margin, marshy plains. No part of the island rises more than a few yards above sea level.

Srīharikota is covered naturally with a dense jungle (as is suggested in Pl. VIIIb). Evidently this growth means that the physiological dryness of the soil is counteracted by the high water table and the forty inches of rainfall which is brought chiefly by the northeast trades or the northeast monsoons as they are called in India. A variety of animal life inhabits the jungle. It ranges from wild pigs to jungle fowl and rats. Tigers rarely visit the island. Then they remain only a day or so, since there are no natural lairs.

These elements then, constitute the setting for the inhabitants (1) an island with its isolating influence, (2) a tropical jungle, (3) abun-

dant wild game, (4) a sandy soil. Let us see what response the people have given to each of these influences.

The Isolation of the Insular Position.—*Cultural Development.*—The isolating influence of the island has been the supreme factor in the lives of the Yānādis. Srīharikota shares with a few mountain recesses in preserving some of the aborigines of India, "pre-Dravidians," as they are called. There is no record of the date of their arrival on the island. It has preserved them as a pure blooded tribe in all their primitiveness. Waves of conquest, waves of caste, waves of religion and of culture have swept over India and left these people untouched. For centuries currents of commerce on both sea and land have flowed past the island even within sight, but without effect on these people.

The Yānādis show the effects of their isolation in many primitive customs. (1) They have only attained a primitive hunting and fishing stage in their development. They have no weapon except a chance stick. They catch game by running it down. They dive and catch fish that burrow in the sand. (2) Their religion is that jungle of unhappy superstitions called "animism." They may be said to worship only on occasions such as weddings and funerals. (3) Their primitiveness is also emphasized by their habit of eating raw food or that merely scorched or heated. They make fire by friction as is shown in Pl. Va. (4) Although they are surrounded by water they have never made or used rafts or boats. It may be that the usual turbulence of the surrounding waters is in part responsible. (5) Their bodies and clothes are never washed. In Pl. VIIa the gray of their dirty clothing is shown in contrast to the white of the interpreter's turban. The government has introduced among them the "dhobey," the Indian washerman, with the hope that they might get the habit. (6) Conjugal relations also indicate a primitive people as has been pointed out by Thurston.[1] The Yānādi marriage is, as one would expect, a somewhat free and easy affair. In contrast to Hindu practise it is generally arranged by the inclination of the contracting parties, and is readily dissolved at the caprice of either. The marriage ceremony is no indispensable necessity. Usually girls marry as soon as they reach puberty, as is suggested by Pl. IIIa. Pregnancy before marriage is no crime. Polygamy is common.

The Response to the Jungle.—*The Plant Products.*—The low stage of culture of the Yānādis has one contrasting feature. They have a wide and practical knowledge of their jungle. Every kind of tree, herb and vine has a name. The properties of each are as well known to them as the letters of our alphabet to us. They gather roots, fruits, leaves and honey for their food and know well the best season for

[1] Castes and Tribes of Southern India, Madras, 1909, VII, 423 et seq.

each variety and where it grows best. They have learned by experience the properties and uses of herbs and roots in medicine. Every ache and pain has its supposed remedy in the jungle flora. Fortunately there is no tree in the jungle that readily yields juices that can be fermented into intoxicating drinks. Therefore the Yānādis are by necessity a temperate people.

This expert knowledge of the jungle led the government in 1835, when it took possession of the island, to employ the Yānādis in collecting minor forest products. In return for their labor the government at first paid them in clothing, grain and money in order that their position might be improved. The employment has continued to the present. They collect chiefly *nux vomica*, soap nuts, tamarind, rattans, sarsaparilla roots, barks that are still used in South India as dye-stuffs, and various leaves, roots, and bark that are marketed in India or elsewhere for medicinal purposes. A forest officer representing the government pays them according to the quantity they bring in. Each person earns about four cents per day. This information and other interesting items were given the writer of this paper by C. Ballayya Nayudu, the forest officer in charge at Srīharikota. He has recently set forth the forest conditions on the island in a brief paper.[2] A group of collectors of minor forest products is shown in Pl. X.

After the government had induced the Yānādis to collect minor forest products it introduced coolies from the mainland to cut firewood to be sent to Madras City, and to teach the Yānādis the art. But they worked under protest. They preferred to be let alone to enjoy the wild life of the jungle. Gradually however they got accustomed to it and now do better work than the immigrant coolies. A group of workers is shown in Pl. VIIb. In this forest work they now earn about four cents per day. With the few cents earned in forest work they buy trinkets (Pl. IV), an occasional pot for cooking purposes or a basket for collecting their jungle foods, and rarely a bit of cloth for clothing. A little money goes to the Yānādi "priest" for exemption from being annoyed by some jungle devil or ghost.

The Running Ability of the Jungle People.—The game of the jungle is an important source of food. From ten to twenty people may combine to follow the footprints of animals or birds. After they are traced out, the animal is chased until tired out and then killed. The flat sandy island offers no effective hiding place for animals. In the case of birds it is necessary for one man to climb a tall tree in order to direct the others as the bird is put to flight by beaters and seeks safety in another place. After many flights the jungle cock, for instance, is tired out, caught and killed. But it has taken many people an hour or so to hunt one creature. This method of hunting and the

[2] "Indian Forester," Sept. 1910, 515-521.

plain on which they live have developed the Yānādis into good runners. Hence the government employs them in running with the freight cars on the narrow gauge track that is used to collect firewood from several parts of the island. The work is shown in Pl. VIIIb. The fleet foot is also an asset to those who have migrated to the mainland. There they are occasionally hired to replace ponies in hauling passenger vehicles, the so-called "pony jutkas." When hauled by these men they are called "Yānādi jutkas." Such a vehicle is shown in Pl. XII. The Yānādi jutka is far more comfortable than the pony jutka, so skilful are the pullers and pushers.

The Response to the Sandy Soil.—Probably the most unique and interesting response that the Yānādis yield to their simple environment is in reference to the sandy soil. Since the Yānādis have no floors to their huts, as is suggested in Pls. IIIa-Va, and no mats, beds nor chairs, and since they wear neither shoes nor stockings, it may be said that they are intimately in contact with sand all of the time. It is literally true that they are born on sand, sleep on it, live on it, die on it and are buried in it.

Susperstitions and Customs.—It is expectable, therefore, to find that the sand plays a part in many of their superstitions and customs. Here are two samples. As a punishment for adultery, the unfaithful woman is made to stand out in the hot sun on the hot sands for a whole day with her legs tied together and with a basketful of sand on her head. The Yānādi in the forest sharpens the cleaver the government has loaned him to trim trees by whetting it on a flat piece of wood sprinkled with sand grains, as in Pl. VIIb.

Footprints and Honesty.—The remarkable ability to track animals the Yānādis possess is a response to the sandy soil. The sandy soil faithfully preserves footprints much better than our dry seashore sands. The Yānādis are able to identify the footprints of individual people as well as of different kinds of animals. A person is known from the footprint he makes. The writer had the opportunity again and again of testing this ability of interpreting tracks. It would seem that the Yānādis tell human footprints as readily as we tell faces. The headman of one village I visited was able to name the footprint of not only every man, woman and child in his village, but that of everybody in the nearby villages as well. Some of the Yānādis are able to identify a footprint after they have associated it with the owner only once. Of course it must be remembered that few people visit the island because of its isolation. It must further be recalled that it is the bare foot that makes the print and feet have as much individuality as hands.

There is evidently a relation of cause and effect between the sandy

soil that preserves foot prints and the remarkable honesty of the Yānādis. The forest range officer of the island and the judge that occasionally visits the island to hold court, both Hindus, agree that the Yānādis are noted for their honesty. It would seem that the sand may be responsible for this one feature of high ethical standards. No person steals since his footprints so identify him that he could easily be traced and found. When the government first induced the Yānādis to work in the forest some seriously objected and ran away from their own village. But they were speedily tracked by the headman and brought back. Even where they had crossed ponds in blowout basins the headman had no difficulty, as he walked around the margin till the tracks reappeared. This illustrates the ease with which thieves might be run down.

This relation between the sandy soil and honesty is brought into conspicuous relief when one studies those members of this same Yānādi tribe that have migrated to the mainland where the soil is laterite. There, where the soil does not retain footprints, they are notorious thieves and robbers. In this respect they are worse than any other people, as is pointed out in the "Gazetteer of the Godavari District."[3] On the mainland they retain the tool which on the island they used for digging roots for food, but here it is used as a jimmy for digging through the mud walls of houses in order that they may enter and steal. Following the principle that "it takes a thief to catch a thief," many of the people of the mainland now employ Yānādis as night watchmen. A group of such men is shown in Pls. XIIIa and XIIIb. A watchman will travel about the group of houses in his charge with such jungle spryness that there is little likelihood for an attempt at burglary and even less of success. But the food he receives daily from the protected people and the few cents at the end of each month are more in the nature of blackmail than an honest wage.

A similar relation between soil and ethics has been brought out in a recent article by Professor W. M. Davis.[4] The case is originally cited by Brunhes.[5] He points out that the sands of the oases of Souf, in northern Sahara, so carefully preserve the footprints of man and animal that the people have become expert in identifying them. They are even able to recognize the tracks of their own camels as different from those of their neighbor's camels. Here, too, honesty is a marked characteristic of these expert trackers in their isolated environment. Brunhes claims the sandy soil has developed honesty. He makes the case stronger by pointing out the comparative dishonesty of the dwellers in the more stony parts of the Sahara. Hence it seems

[3] F. R. Hemingway, Madras, 1907, 192-193.

[4] "Human Response to Geographical Environment," The Bulletin of the Philadelphia Geographical Society, XI, No. 2, Apr. 1913, 1-40.

[5] "La Geographie humaine," Paris, 1910, 515-539.

that the two cases are remarkably parallel. Each surely supports the other.

To return to Srīharikota we must conclude that there the sand spells honesty. There the Yānādis had established a wonderful Bertillon system centuries before Bertillon was born. Records of identification of every inhabitant of the island have been constantly kept in the minds of the people. In Srīharikota even he who runs must give his identification mark. The sand can tell no lie. The sand breeds honesty.

Conclusion.—Such are the influences that are exerted by the simplest part of a simple land form upon a primitive people. It is interesting to contemplate how such an environment would influence the life of an advanced people. How does such an island off the Atlantic coastal plain in North or South Carolina, for instance, affect the life of its inhabitants? This takes us into a different climatic belt; hence the influences of two new factors would have to be untangled. Such a study would be the logical second step into one kind of systematic geography. Present geographical investigations seem to be carried on in a sort of sampling manner. One student of the science samples one field of geography, another selects another corner of the subject to investigate, and so on, all in a seemingly haphazard way. General progress would surely be better fostered if a definite system were to be adopted by a leading geographical society like the Association of American Geographers and if serious students of the science were encouraged to follow out its plan.

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THE EROSIONAL AND DEGRADATIONAL PROCESSES OF DESERTS, WITH ESPECIAL REFERENCE TO THE ORIGIN OF DESERT DEPRESSIONS

WILLIAM HERBERT HOBBS

CONTENTS

Foreword.—*The Psychology of Theory Making in Science.*—The writer has long interested himself in the psychology of the making of scientific theories, and has given some attention to the manner in which the great events of a period, the accepted fashions of intellectual processes in vogue at the time, and the personalities of the dominating scientific authorities, have reacted and interacted to produce what we

sometimes refer to as standard doctrines—the accepted theories. In the field of seismology it is not difficult to show how the so-called centrum theory of earthquakes, which held the center of the stage for half a century (1857-1907) and determined the trend of investigation, is directly traceable to the Crimean War, since it was there that the reputation of Robert Mallet was made in the field of ballistics. On the basis of his researches upon the life of great guns, Mallet was able to obtain the financial support of the Royal Society for a study of the Neapolitan earthquake of 1857, and in his report upon it to carry over successfully to the disturbances within the earth's outer shell, ideas gained from explosions and the propagation of their shocks as harmonic motions through homogeneous media.

The study of glaciers has similarly been given its trend as a consequence of the accident that pre-existing glaciers of continental dimensions were visualized from Alpine glaciers before existing glaciers of continental type had been examined. A great personality and the greatest authority upon the diminutive mountain glaciers of the Alps, was the first to visualize the great glaciers of "The Ice Age," and quite without warrant to carry over to them those attributes which he had found to belong to the small ice streams of the Alps.

It is only natural that the prepossessions of geologists concerning the geological processes of desert regions, should have been largely carried over from the humid regions of temperate zones, with which they had long been familiar and within which geological science had grown up. In America particularly this seems to have been true, notwithstanding the fact that important areas of desert were early studied and described in monographs which have greatly enriched the field of knowledge.

Much impressed by that great work of Johannes Walther, "The Law of the Desert," the writer had felt a longing to visit the deserts of northeastern Africa, to which Walther has devoted so much attention and where complete aridity is perhaps more nearly realized than elsewhere upon our planet. The desired opportunity came in the winter of 1912-13, and the studies then made constitute the basis of the present work.

Acknowledgments.—The author is under special obligations to the Survey Department, Egypt, for copies of valuable maps; to Mr. G. W. Grabham, M. A., Geologist to the Sudan Government, for many courtesies and for acting as his guide in excursions made from Khartum as a center; to Mr. Wright, who at Markaz el Sherikah was in charge of the office of the Corporation of Western Egypt and who gave him valuable assistance in an excursion made in the Oasis of Kharga.

In the later study of the desert stones, the author is under obligation particularly to Professor Edward D. Campbell, Director of the Chem-

ical Laboratory of the University of Michigan, and to William C. Dowd, his Assistant, for a chemical study of the desert rinds. To Dr. A. L. Parsons, Professor of Mineralogy at the University of Toronto, the author is indebted for a study of the hardness of these specimens.

THE CONTRASTED FEATURES OF HUMID AND ARID LANDS.—*The Intricate Patterns of the Erosion Surfaces in Humid Regions.*—Within humid temperate regions, those with which we are best acquainted, the erosion surface of the land is very largely the handiwork of running water, or that of glacial ice subsequently laid under the action of running water. Wherever water has been the sole agent of degradation, the design imprinted upon the land surface is an arborescent tracery cut into the surface—an intaglio—which starting from stem-like grooves at the ocean margin divides and subdivides the area with ever greater complexity as it recedes from it. Most deeply graven at the ocean border, the incisions become both shallower and finer with each succeeding ramification. Though the incisions be cut so deep as to remove all the original surface and so yield a complex of ridges, the pattern is none the less truly preserved as an intaglio.

Glacial ice insofar as it is in small masses and restricted in its action to the trenches of the pattern produced by the action of water, though it modifies the form of the gravings and particularly where they are less deeply incised, does not in any large degree efface the general pattern due to the running water. Quite otherwise is it where ice masses of continental dimensions instead of being restricted to the existing valleys spread broadly over the entire country. By a combination of sculpturing and moulding processes the inherited intaglio is gradually transformed into a cameo, and the pattern which before was arborescent is now hidden beneath a series of raised arcs ranged in sweeping festoon series. So soon as the ice has disappeared, the land surface is usually once more laid under the action of running water, and upon the cameo design there is faintly imprinted an intaglio tracery of arborescent character, but one far less symmetrical and orderly than that which under other conditions is yielded by running water. Sometimes the original deep intaglio is not entirely effaced when the glacial cameo has been raised above it, and the resulting surface is so much the more intricate from its shaping in three successive stages, each with a different pattern. Yet whatever may have been the respective rôles of water and ice in the shaping of a land surface, the intricate tracery of the intaglio which results from river erosion is never entirely absent, affording as it does the most striking contrast between the surface of the lands best known to us and that of the neighboring portions of the ocean floor.

The Simple Models of the Erosion Surface in Arid Lands.—The orderly tracery which is etched into the land surface within temperate humid regions is, however, in sharpest contrast with that of the arid lands. As we have seen, the intaglio pattern is to be ascribed to the selective action of the eroding agent operating under control of definite laws. It is the general absence from the arid lands of an eroding agent of selective character, which accounts for the absence of any similar patterned surface in such regions, and its restriction in semi-arid lands to a narrow marginal hem about the greater depressions. In the true deserts the degrading agents attack the entire exposed surface of the land with nearly uniform vigor, modified only as the materials attacked offer varying degrees of resistance. The main agent is the sun's heat, manifested upon the one hand in large and sudden changes of rock temperature, and upon the other in prevalent strong winds which lift and transport all the finer rock fragments. To these is added at infrequent intervals and locally, heavy downpour and flood-water here likewise largely non-selective in its action, since it travels in the main as sheet-flood either of water or mud.

As regards the larger relief features in desert lands, they are for the most part broad and notably flat areas which pass from one level to another, not as a rule in curving slopes as is so common in humid regions, but through a series of abrupt steps or terraces joined to each other by the even inclines of talus. We miss also, that lack of balance in the accomplished excavation which is so characteristic a feature of the land sculpture in humid regions. Within the arid lands the removal of rock materials has yielded vast flat-bottomed depressions within the surface which are shut in by steep walls and have been variously described as Djufs,[1] *Wannen* (pans),[2] bolsons,[3] and intermont plains.[4]

Desert Weathering Contrasted with that of Humid Regions.—In order properly to understand the erosional and degradational processes of deserts, one must first divorce his mind from the preconceived notion that weathering processes are the same in arid countries that they are in the more familiar humid temperate regions. Of the two broad classes of weathering processes, chemical and mechanical, the former generally described under the term decomposition, are largely dependent upon the presence of nature's common solvent medium, percolating water. That chemical reaction may occur, an intimacy of

[1] Karl A. v. Zittel, Beitraege zur Geologie und Palaeontologie der libyschen Wüste, etc., Palaeontographica, vol. 30, 1883, pt. 1, pt. 9-10.

[2] Albrecht Penck, Morphologie der Erdoberfläche, vol. 2, 1894, pp. 235-251.

[3] R. T. Hill, Topographic Atlas of the United States, folio 3, 1900, p. 8. Redefined by C. R. Keyes, Am. Jour. Sci., vol. 165, 1903, pp. 207-210.

[4] C. R. Keyes, Rock-floor of the Intermont Plains of the Arid Regions, Bull. Geol. Soc. Am., vol. 19, 1908, pp. 63-92.

contact of the reacting substances is required which demands a fineness of subdivision such as is reached only in fusion or solution. Fusion being here out of the question, decompositional processes are in weathering almost entirely restricted to those districts where rainfall is abundant; their place in arid lands being taken by the mechanical processes of disintegration and by certain reactions apparently in part at least of a chemical nature which are restricted to the outermost skin of the rock and yield the well-known protective rinds.

The disintegrating processes of exfoliation (often controlled by joints to produce segmented columns), crumbling disintegration, diffission (Walther's term, *Insolation*) and case-hardening, are well described in German by Johannes Walther,[5] and the reader unfamiliar with that language may perhaps be referred to the author's Earth Features and their Meaning.[6]

Case-Hardening of Rock.—*Chemical and Mineralogical Study of Protective Desert Rinds.*—At various localities, but particularly in the area northwest of the Pyramids of Giza, about Luxor, in the Great Oasis, and near Khartum, many specimens of loose desert stone were collected from the surface armor of pebbles upon the desert floor, specimens having rinds which represent various differences in appearance, in thickness, and obviously in the chemical changes which have taken place in them (See Plates XIV and XV). The rinds of two of these specimens have been subjected to special study with reference to changes in hardness and in chemical composition which they have undergone. The chemical study has been conducted by Professor Edward D. Campbell, Director of the Chemical Laboratory of the University of Michigan, the analyses being made by his assistant, Mr. William C. Dowd, B. S. The same specimens have been examined with regard to hardness by Professor A. L. Parsons, of the University of Toronto with use of the special form of schlerometer which he has devised.[7]

A "Soft" Rind.—One of the specimens studied is a brownish yellow variety of dolomite with a rind which has an average thickness of a centimeter or more which appears upon the specimen as a cornice-like marginal extension where undercut by the action of the driven sand (Plate XIVa). When broken through the specimen shows the rind to be somewhat more strongly colored by the iron stain characteristic of the entire specimen.

The analyses of core and rind made upon this specimen by Mr.

[5] Das Gesetz der Wüstenbildung, 1912.

[6] Chapters on Weathering and on Deserts.

[7] A. L. Parsons, A New Schlerometer, *Am. Jour. Sci.*, vol. 29, 1910, pp. 162-168.

Dowd, revealed the interesting fact that though the rock as a whole is a dolomitic limestone with a ratio of dolomite to calcite molecules of about 6:1, the thick rind is by contrast a nearly pure calcite.

ANALYSES OF DESERT STONE AND ITS RIND FROM SPECIMEN COLLECTED IN THE LIBYAN DESERT TO THE NORTHWESTWARD OF THE GREAT PYRAMIDS, BY WILLIAM C. DOWD, B. S., ASSISTANT IN CHEMISTRY, UNIVERSITY OF MICHIGAN

	Interior of Stone	Theoretical Comp. of Dolomite ($CaCO_3$, $MgCO_3$)	Rind	Theoretical Comp. of Calcite ($CaCO_3$)
SiO_2	0.19	—	0.51	—
Al_2O_3	0.05	—	0.26	—
Fe_2O_3	0.34	—	0.38	—
MnO	0.04	—	0.03	—
CaO	33.74	30.4	54.92	56.0
MgO	18.34	21.7	.28	—
Loss on Ign.	47.29	47.8	43.64	44.0
	99.99	100.0	100.02	100.0

It is at first rather surprising to learn from these analyses that the rind, which has offered more resistance to the bombardment by the grains of driven sand, is very much softer than is the normal rock: Confirmation of this is furnished by the determinations of hardness made by Professor Parsons after artificial surfaces had been prepared and carefully polished by a lapidary. Some difficulty was encountered in securing smooth surfaces owing to the presence of small pittings, in consequence of which the tests for hardness gave results which varied between rather wide limits. The average of twenty-seven readings made upon the dolomite interior corresponded to a pressure of 5.1 grams, whereas the average of thirty-two readings made upon the calcite rind of the specimen corresponded to a pressure of 2.52 grams. The rind would appear therefore to be only about one-half as resistant to abrasion of this type as is the interior. None the less the specimen indicates with sufficient clearness that resistance to the bombarding action of sand grains is notably greater for the rind of soft calcite than it is for the core of harder dolomite. Professor Parsons has drawn my attention to the fact that the wear upon rubber tubing used in sand pumps is greater the harder the rubber, and that paper is so resistant to a sand-blast that it is used as a guard when letters are cut upon glass by this process.

The elimination of the magnesium carbonate from dolomite in the rind producing process, is obviously of considerable interest. Professor Campbell has offered the following suggestion:

"Magnesium carbonate is much more readily dissociated than is calcium carbonate, so that one might expect that it would be removed

more readily than the latter under the desert conditions to which these limestones have been subjected."

The carbon dioxide which results from the dissociation of the magnesite molecule, would be lost in the atmosphere, and it is not improbable that the finely divided magnesium oxide would be sucked out of the rind and carried away during high winds.[8] That this process of elimination of magnesium carbonate has been accompanied by a recrystallization of the calcite residue, is abundantly proven by examination of a microscopic thin section which includes both core and rind, for the calcite of the rind is in coarser grains than is the dolomite of the core.

A Black Rind.—The other desert rind which was especially examined, is found upon a specimen of a grey variety of Mokattam Limestone from the same district, which in the unaltered interior reveals in the microscopic section the silicious infusoria which are characteristic of certain layers of this formation. The rind of this specimen is in three distinct layers, the outermost lustrous black and a millimeter in thickness, immediately beneath which is a red layer of oxide of iron of the same thickness approximately. The main portion of the rind has a thickness of several millimeters on the average and is made apparent upon the fractured surface of the specimen by its color, which is somewhat lighter than the unaltered rock.

The material for analysis of the rind was obtained by grinding away the core material from a fragment of rind and core. It represents, therefore, the rind with, probably, some small portion of core attached.

ANALYSES OF DOLOMITIC LIMESTONE AND ITS DESERT RIND, FRAGMENT FOUND IN THE LIBYAN DESERT NORTHWEST OF THE GREAT PYRAMIDS OF GIZEH.
ANALYSES BY WM. B. DOWD, B. S.

	Interior	Rind
SiO_2	7.04	50.99
Al_2O_3	.49	1.33
Fe_2O_3	.08	.22
MnO	Trace	.14
CaO	43.96	21.96
MgO	6.47	3.79
Loss on Ign	42.07	21.33
	100.10	99.76

These analyses by Mr. Dowd show the unaltered material of the interior of the specimen to be a dolomitic limestone in which the magnesite molecule is admixed with the calcite molecule in about the proportion of 1:3, the imbedded silicious infusoria giving a silica content of seven per cent of the whole. The impure rind is shown

[8] Cf. Sickenberger, Zeitsch. d. d. geol. Gesell., 1889, p. 314.

to be about one-half silica and one-half dolomitic limestone of approximately the same composition as that of the interior.

A section of this rind with the attached portions of the core was digested for two weeks in a mixed solution of five per cent nitric acid and ten per cent hydrochloric acid, the residue being taken from the menstrum at intervals for scraping and washing. At the end of the period there remained a residual shell of a dirty white color corresponding in thickness to the sub-surface rind in the original specimen, and with a somewhat brownish outer surface. Only 2.43 per cent of this shell remained as an insoluble residue after one hour's digestion in a five per cent solution of nearly boiling hot sodium hydroxide. This ready solution in caustic soda indicates that the silica is opaline, and examination of the thin section confirms this view. In the section the silica is revealed in the interior portion in the form largely of organic rests as chalcedony. These infusoria can be observed to extend into the rind without noticeable change of character, whereas the remaining portion of the rind shows the dolomite of the core to be in large part replaced by opaline silica, which affords a birefringence of the rich blues and yellows to contrast with the calcite colors of the higher orders. In addition the rind is considerably stained with ferrite and is on this account easily differentiated from the core when examined in ordinary light.

The development of opal within the rind confirms observations made in other desert regions, so that opal has come to have the value almost of a fossil in indicating arid climatic conditions, a distinguishing characteristic which it shares with gypsum. In view of the extreme aridity of the region where the specimens were found, the writer inclines to the view that the moisture enters in the process of the change not as rain but much more probably as dew.

The studies by Professor Parsons of the hardness of this specimen, indicate for the interior portion as the result of four tests which are in very close agreement, a hardness corresponding to 2.8 grams of pressure, about the hardness of calcite. Three almost equally consistent tests made upon the inner rind gave a hardness corresponding to 1.73 grams of pressure, or something more than half that of the unmodified interior rock. The thin red layer between the innermost rind and the outermost black varnish was almost too thin for testing, but a single scratch gave the result 1.6 as against the average 1.73 of the main inner rind, which indicates with much probability that it is mainly of the same material though strongly colored with hematite. These results are somewhat puzzling in view of the larger percentage of silica in the rind as compared to the core, and they perhaps indicate the difficulty in applying tests of hardness to aggregates of such different bodies as silica and carbonates.

Sand-Blast Erosion.—*Observed Range of More Effective Action.*—Oddly enough little attention seems to have been directed to sand-blast erosion by geologists, most general texts laying stress only upon the differential erosion effects indicated by the well-known "stone lattice" which is developed wherever notable differences of rock hardness correspond to a more or less definite pattern. Moreover, the mushroom rocks (*Pilzfelsen*) so common in deserts, seem generally to have been explained by the assumed existence of a stratum of less resistant rock near the level of the general surface, which layer has in consequence first fallen a prey to weathering processes. While without doubt in many instances, such, for example, as those figured by Walther,[9] the weathering of a less resistant layer near the ground level may be sufficient explanation for the canopy-like overhang, it is believed that in many other instances the mushroom forms are to be accounted for solely by sand-blast erosion strictly limited in vertical range and close to the level of the ground.

The writer was first strongly impressed by the narrow range in effective action of the natural sand-blast from observations made in the Great Oasis of the Libyan desert, where the cast-iron telegraph poles lining the railway were well burnished by the flying sand to a height above the ground of only about a yard. Here also the thick adobe walls of the ancient Roman fort near Jebel Um el Ghenneiem known to the natives as "El Deir," are deeply undercut by the same process with the upper limit of effective abrasion essentially the same as noted on the telegraph poles, except where accumulations of sand have locally raised the surface of the ground (Pl. XVI).

To the north of Khartum and east of the Shabluka gorge of the Nile, the granite knobs which as "island hills" rise out of the great plain, have been beautifully burnished by the sand-blast to the height of about a yard, at which elevation the polished zone meets the remaining upper portion of the granite surface in a fairly sharp boundary. Even from a considerable distance the lower polished zone is plainly outlined against the dark brown surface above (Pl. XVIIIb).

Sphenoidal Elongated Ridges Fashioned by the Sand-Blast.—Wherever the winds maintain a constancy of direction throughout the year, ridges of peculiar form result from sand-blast erosion. Throughout a large area of the Libyan desert the direction of winds throughout the year varies through a small arc only to the westward of the meridian, and hence such ridges as are carved by the sand erosion take on definite forms. Where the rocks are of little strength, these ridges are carved with comparative ease, and the limited vertical range of the action causes undercutting wherever projecting masses of rock

[9] Johannes Walther, Das Gesetz der Wüstenbildung, 2te Aufl., 1912, figs. 101-105.

exceed in height the yard or thereabouts to which effective abrasion extends. Particularly fine examples are supplied by the eroded lacustrine beds exposed near Markez el Sherikah in the great oasis. These weak clayey beds are intersected by a rectangular system of vertical joints, and in consequence the windward surface, as it has been undercut by the sand-blast, has been fashioned on these planes and left as a nearly vertical cliff sometimes notched at the base as is a sea cliff. That portion of the sand which is swept around and over the projection scours it upon the sides and lee surface and shapes it eventually in general conformity to the lines of stream flow (Pls. XIX and XX). The form assumed under the action of the sand-blast is an elongated sphenoid strikingly unsymmetrical, with longer axis directed with the wind and having the steep and small face to windward. Where groups of these features appear upon the floor of the desert, they strikingly suggest a school of porpoises emerging at the same instant for their leaps out of the water (Pl. XIX). Low secondary features which have been sculptured by sand-blast in the deserts of Central Asia are described by Sven Hedin under the term *jardangs*, and here also as the winds blow with much regularity from one quarter they possess a very definite and constant topographic form.[10]

Upon the broad hamada which separates the Great Oasis in the Libyan desert from the rift of the Nile, the "glass hard" limestone which forms its upper capping layer, has in local areas and under constant northerly winds been fashioned into unsymmetrical ridges by the flying sand, but since the sculpturing process goes forward here much less rapidly than in the case of the weak lake beds of the oasis, the original surface has been much less profoundly altered and the ridges present less uniformity in contour. It is worthy of note, however, that the lower layers for a few feet above the general level of the hamada consist of the strongest rock, whereas above this layer there occurs a relatively soft bed with numerous hard flinty concretions. These latter through undermining by the sand-blast have in some areas been liberated from their matrix in large numbers and lie scattered thick over the surface, thus resembling a field of watermelons, and they are in fact so called (*el botiq*) by the Bedouins.

Where the surface features are fashioned from the hard lower layer, the projections which result often lie close together so that the sand-laden wind has passed between them as through bellows pipes. If these obstructions do not exceed a yard in height, the windward or stoss ends are found beautifully polished to the top, but if much higher a rough unshaped upper surface may often be seen.

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[10] Sven Hedin, Scientific Results of a Journey in Central Asia, 1899-1902, vol. 2, 1905, pp. 238-242, pls. 24-27.

Rate of Undercutting by Sand-Blast.—During the windy days of early summer, erosion by flying sand within the area of the Great Oasis is excessively rapid. Ball tells us that a piece of tin plate put out to the blast for two days had all the coating removed, and that glass bottles in the same time were made quite dull by the scratching action of the driven sand.[11] On the protected surfaces of rock in the same region, on the other hand, erosive action has been so slight that after 1,400 years inscriptions drawn in red ochre are entirely legible. A quite remarkable pair of examples of rapid sand erosion on projecting buttes has been furnished by Obrutchev.[12]

A good measure of the rate of sand erosion on well-made adobe was furnished by the corner posts of a cemetery lot at Markaz-el-Sherikah that had been erected about a year before the writer's visit. Owing to the constancy of the wind direction, these posts had been undercut about the northwardly directed angle only, and there to a depth near the ground of five to six inches. The eroded portion extended up from the ground about two and a half feet, and wherever small pebbles had been included in the mud of the adobe these had locally protected the material behind it and so yielded small hoodoo-like headed pillars directed toward the wind and some three inches in length (Pl. XVIII).

Such slender "demoiselles" resulting from the imbedding of harder nodules within rocks whose surface has been drilled away by natural sand blast, have been described by Walther. Especially beautiful examples of such structures were collected by the writer from the notch near the summit of Dj. Um. el Ghenneiem near the eastern wall of the great Oasis. The rock is the compact Eocene limestone and the capping nodules the numerous imbedded shells of *Operculina Libyca* (Pl. XXI). The spines are sometimes fully an inch in length, and apparently as a result of local wind currents beneath the zigzagging escarpment of the eastern wall of the depression the spines project in nearly opposite directions from certain angles of the rock surface (Pl. XXIb). An example of a relief pattern supplied by the hard phenocrysts of a rhyolite is reproduced in Plate XXIIb.

Possible Explanation of the Limited Vertical Range of Effective Sand-Blast Erosion.—When it is borne in mind that within desert areas particles of sand are during sand storms raised to very considerable heights, one is at first surprised to find that the efficiency of sand-blast erosion should here be both so limited and so definite in range. For this there are probably two principal causes. It is certainly true that the size of the lifted grains of sand falls off

[11] John Ball, Kharga Oasis, Its Topography and Geology, *Geol. Sur. Dept.*, 1889, part 2, Cairo, 1900, p. 92.

[12] Eolovyi Gorad (Russian), 1911, figs. 13 and 14.

rapidly as elevation above the ground increases beyond a few feet, and that only the larger grains are competent to bombard obstructing surfaces with much force. For the smaller grains adhesion and friction with the air is relative to their mass, so large that they acquire but little momentum, whereas for the larger particles the momentum (which measures the striking force) is for each particle more nearly equal to its mass into the square of the wind velocity. But erosion by sand-blast depends upon the number of hits as well as upon the striking force of each sand grain, and it is the lower zone of the air in which the density of the sand-air complex is particularly large. Within this zone during a strong wind the air highly charged with sand may be looked at in a somewhat different way and regarded as a fluid whose density is two or three times that of the air alone (.0048 to .0072).[13]

Added to the chipping effect of the sand bombardment upon an exposed rock surface, there is the scouring effect of the grains which strike glancing blows.[14] Now the chipping and scouring actions both depend upon the greatly increased velocities within the eddies which exist in the lower layers of the air, and it is highly probable that the upward limitation of eddies having sufficient strength to lift the larger sand grains has fixed the sharp upper limit of more effective sand-blast erosion. To realize how great may be the velocity difference between the eddies and the surrounding air, one has only to consider the contrast between the larger local eddies and the surrounding air at the time of destructive storms.

Air and water are fluids which are controlled in their movements by similar laws, and the problems of transportation of debris by these fluids differ chiefly in the different specific factors of viscosity. For water flow as modified by friction on solid surfaces, a valuable experimental study of the formation of eddies was made by Reynolds in 1883.[15] It was found that the less viscous the fluid the more prone it is to eddy, that eddying is excited by any roughness of the surface over which the current flows, and by any lack of steadiness of the current itself. It was further shown that there is a critical velocity of the current above which eddying takes the place of a direct forward flow.

Much knowledge of the nature and the dimensions of the air eddies near the surface of the ground has been supplied by Cornish in a

[13] Herbert Chatley, The Force of the Wind, London, 1909, pp. 77-78.

[14] Chatley has given a rough formula for the scouring action, namely AV^2 (.00001 to .000015), where A is the area wetted (in water) in square feet and V is the velocity of the wind in feet per second (l. c. p. 79).

[15] Osborne Reynolds, An experimental investigation of the circumstances which determine whether the motion of water shall be direct or sinuous and of the law of resistance in parallel channels, *Phil. Trans.*, 1883, pt. II, pp. 935-982.

study, in part experimental and in part observational, the latter carried out in the Egyptian Desert.[16]

Cornish's experiments show that over a flat sand surface the effect of a strong current of air is to produce ripples of sand corresponding in position in the plan with the eddies which are found in the lower stratum of air, and that the wave length and amplitude of the ripples increase steadily with the time which the wind blows over the surface. The ripples run transversely to the wind direction and are frequently striated along the wind direction. The air motions within the eddies thus appear to resemble the motions of ranks of hoops traveling forward with approximately the same velocity. When the force of the

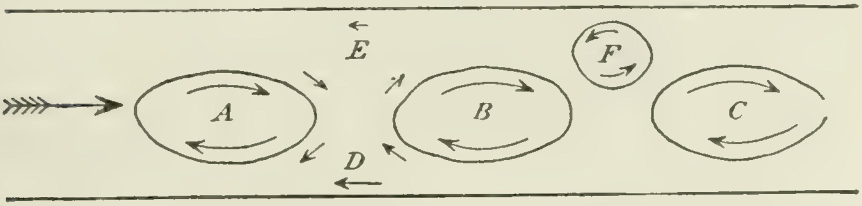


FIG. 1. Ideal longitudinal section of a stream, illustrating the hypothesis to account for the sub-surface position of the level of maximum velocity (after Gilbert).

wind falls off the ripples fill and becoming less distinct, the fall of a shower of sand soon smoothes out the surface. But this is again quickly covered with ripples under the renewed action of a strong current of air. A limit seems to be set to the size of the ripples, for any increase in height of the windward ridges though increasing the strength of the eddy directly above and causing a forward saltation of the grains, reduces the height of the ridge at the same time that it contributes toward the filling of the trough in front. A lateral transverse differentiation in the force of the eddies, which is rhythmic as regards space, produces undulations within the ripples and in some cases the horseshoe-like depressions in the sand which have become known as *fuljes*.

Though Cornish appears to find that heterogeneity of the sand is necessary for the formation of ripples—the larger grains producing small eddies which are sufficiently powerful to lift the smaller grains in the vicinity—the work of other observers indicates that eddies are

[16] Vaughan Cornish, On the formation of sand dunes, *Geogr. Jour.*, Vol. 9, 1897, pp. 278-309. See also with reference to water ripples H. Blasius, Ueber die Abhängigkeit der Formen der Riffeln und Geschiebebänke vom Gefälle, *Zeitsch. f. Bauwesen*, Vol. 60, 1910, pp. 466-471, Atlas, pls. 49-50. The mathematical side of the subject has been developed with literature references by A. E. H. Love, Hydrodynamik, Encyklopaedie der Math.-Wissensch., Vol. 4, Mechanik, (vol. 1), pp. 76-83 et seq., and for air especially by S. Finsterwalder, ibid, Aerodynamik, pp. 149-170.

produced in the air even over a smooth surface. Gilbert explains this as due to the couple caused by friction upon the floor or ground, which retards the forward movement of the air; and he makes this fact and the existence of secondary reversed vortices immediately above account for the sub-surface position of the level of maximum velocity of current.[17] (See fig. 1).

We are inclined to believe that in this distribution of the eddies is to be found the best explanation for the sharp upper limit of effective sand-blast action, the limit falling at the upper level of the primary "forward" eddies, at which level they are replaced by the secondary "backward" eddies. (Fig. 1.)

To no one are we more indebted than to Professor Brunhes for emphasizing the importance of the eddy in erosional processes both sub-aqueous and sub-aerial.[18]

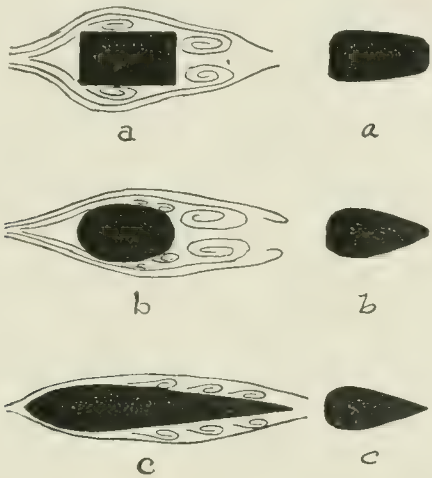
Side-lights upon the Position of Eddies in Fluids Supplied by the Field of Ship Construction.—Experimentally the study of eddies within air currents above the desert may be approached from an entirely different angle. The general similarity of the mechanical conditions within the two types of fluids has already been made use of and conclusions drawn. In a wholly different field, that of ship construction, experiments have been conducted by Ahlborn which are most illuminating.[19] As regards the formation of eddies within the fluid it is obviously immaterial whether the fluid is in motion and the obstruction stationary, as in the desert problem; or the fluid be stationary and the obstructing solid body drawn through it. In Ahlborn's experiments bodies of various shapes were drawn at uniform rates through water within a tank, and by means of special illumination of particles of lycopodium powder which was disseminated in the water, the effects were photographed by a moving camera. By attaching coarse grains to the surface of a board, eddies of sufficient amplitude were produced to show plainly in the photograph (Pl. XXIIIa). A board placed at right angles to the direction of translation and drawn through the water, reveals in the photograph the wedge of dead water which forms in front and a bi-lateral system of eddies upon the rear

[17] G. K. Gilbert, the transportation of debris by running water, *Prof. Pap. U. S. Geol. Surv.*, No. 86, 1914, p. 248, fig. 83.

[18] Jean Brunhes, Sur quelques phénomènes d'érosion et de corrosion fluviales, *Comptes Rendus*, Vol. 126, 1898, pp. 557-560. Le travail des eaux courantes, *Mem. Soc. Fribourgeoise des Sciences Naturelles*, Fribourg (Suisse), 1902, pp. 153-224, figs. 1-10. Sur le rôle des tourbillons dans l'érosion éoliennes, *Comptes Rendus*, Vol. 135, 1902, pp. 1132-1134. Erosion tourbillonaire éolienne. Contribution a l'étude de la morphologie désertique, *Mem. della pontif. Accad. dei Nuovi Lincei*, Vol. 21, 1903, pp. 129-148, pls. 3-4.

[19] Fr. Ahlborn, Hydrodynamische Experimentaluntersuchungen, *Jahrb. der Schiffbautechnischen Gesellschaft*, Berlin, Vol. 5, 1904, pp. 417-453, figs. 1-29.

side (Pl. XXVb). A later study dealing especially with the eddies is even more instructive from the point of view of the desert geologist.[20] Solid bodies of different shapes were drawn through the water and the dead wedge in front and the system of eddies behind shown in photographs. Those which are of most interest in showing the eddies yielded by obstructions which project above the general level of the desert floor have been schematically represented in Fig. 2. These studies seem, therefore, to have supplied an explanation for the peculiar forms of the *Jardangs* described by Hedin and for the porpoise-like features which are produced by wind erosion from a single direction out of the lake beds exposed near Markaz-el-Sherikah in the Libyan Desert (Pls. XIX and XX).



F2|7. Eddies about obstructions of various forms drawn through water (based on Ahlborn).

The ruffled Surface of the Desert Rock.—The experiments and observations above described to show the character of eddies produced in the lower stratum of air over the desert floor, have shown that these eddies have a motion of forward translation which is reflected in layers of sand by the rippled surface. Just as the initial irregularities in the surface of the sand layer induce the formation of eddies in the air layer above, so the irregularities of surface of the desert rock when in coherent masses must likewise be responsible for the formation of eddies above, and these eddies armed with grains of sand are capable of accomplishing erosional work upon an altogether surprising scale. Unlike the eddies over sand-dunes, these are fixed in position,

[20] Fr. Ahlborn, Die Wirbelbildung im Widerstandsmechanismus des Wassers, ibid, Vol. 6, 1905, pp. 65-81, Figs. 1-23. Die Widerstandsvorgänge im Wasser an Platten und Schiffskörpen, Die Enstehung der Wellen, ibid., Vol. 10, 1909, pp. 370-436, pls. 1, 2, 7, 8.

and the erosional work which they accomplish is dependent not alone upon the wind velocity and the charge of sand, but is subject to a steady acceleration as the rock surface takes shape under the eroding process. The character of this surface, which is developed in great perfection at many localities over the great Libyan hamada, can in no way be so well described as by comparison with the ruffled surface of the sea while a fresh breeze is blowing (Pl. XXVa). This surprising likeness is undoubtedly due to a common cause—the readiness of the water surface quickly to take shape in response to the air eddies above it, thus in large degree making up for the brief time interval during which the system of eddies may be considered to be stationary in position.

As regards the rock surface the scale of the rufflings varies between wide limits, and the elongated hollows of the surface in the rock,

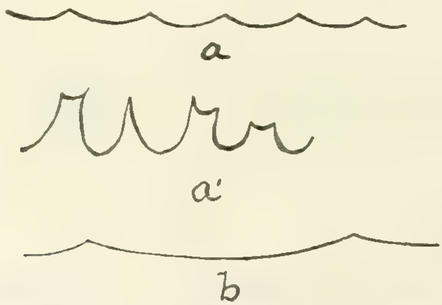


FIG. 3. a, Tranverse section of early ruffles upon the rock surface. a, Mature ruffles. b, Longitudinal section of early ruffles.

as in the water which is suggested for comparison, are of many orders of magnitude occurring together, the smaller superimposed upon the larger (Pls. XXIIIb and XXIV). Owing to the fact that the stationary eddies may continue their shaping influence almost indefinitely, sharply accentuated types of relief pattern are produced for which there is no parallel in the ruffled surface of water (Fig. 3a). It would therefore be proper to speak of early and mature rufflings of the rock surface. In a rock so dense as the finely crystalline limestone which forms the upper layer of the Eocene and likewise the mesa-capping of the Libyan hamada, the polish of the surface becomes so perfect that it gives a blinding mottled glare under the desert sun.

It is interesting to note that rock surfaces similarly ruffled have been produced by the eddies in cataracts, though these surfaces had been seldom brought to the light previous to the modern epoch of gigantic hydro-electric projects. Under the name of a "new process

of fluvial erosion" Lugeon has described such surfaces from the Yadkin River in North Carolina.[21]

Evolution of Ideas Respecting the Origin of Desert Depressions.—*Conception of the Abandoned Sea-Floor.*—Theories of origin of desert depressions which have been offered by geologists, have obeyed the rule of custom in that they have pictured the most familiar scenes to those with whom they originated. Always within easy access to the sea, as European geologists have been, its aspects were familiar, and two noteworthy peculiarities of deserts—the deposits of salts and gypsum and the dunes of sand—were quite naturally brought into prominence with their suggestion of the former presence of the sea.

It is upon the same plan that the simple nomad of the desert has builded his theories, for when Sickenberger asked the Bedouins in his caravan what agent had shaped the country about them, they replied without hesitation, "*El hauer,*" the wind.

The idea that the Great Sahara is the dried bed of an ocean is as old as Erastothenes and Herodotus, and the existence of this ocean was even within five and thirty years a burning question among European geologists, the ingenious theory of Escher von der Linth having held that through preventing the Alpine Föhn the Sahara Sea had brought on the "Ice Age" of Europe. This supposed origin of the Föhn in Africa we now know to be erroneous, but it was not until 1883 that Karl von Zittel, the geologist of the Rohlf's Expedition to the Sahara, was able to lay this specter of the desert and prove that the much discussed Sahara Sea had been a creation of the imagination.[22]

That deserts have originated in arms of the sea is, however, a general notion which has been applied to one desert basin after another and adhered to with varying degrees of pertinacity. To the deposits of salt and sand, which had been brought forward as conclusive proofs, there was generally to be added the evidence of former strands which were clearly the work of water waves. In no small measure the tenacity with which this doctrine was held is to be ascribed to the then generally accepted theory of Ochsenius[23] of the origin of salt deposits. With the aid of this well known theory, much magnified barrier beaches were erected at convenient times so as to transform arms of the sea into interior basins to be subsequently evaporated, the bars being let down again with almost human prevision as the

[21] Maurice Lugeon, Sur un nouveau mode d'érosion fluviale, *Comptes Rendus*, Vol. 156, 1913, pp. 582-584. Le striage du lit fluvial, *Ann. de Géographie,* Vol. 23-24, 1914-15, pp. 385-393, Pl. 11, Figs. 1, 2, 4.

[22] K. A. v. Zittel, l.c., pp. 31-42.

[23] C. Ochsenius, Die Bildung der Steinsalzlager und ihrer Mutterlaugensalze, etc., Halle, 1877, pp. 172.

state of concentration of the salts made such a change either necessary or desirable.

Supposed Tectonic Origin of Desert Basins.—That deserts are often interior basins separated by plateaus or by mountain ranges from the sea was early recognized, and in going farther back to explain their origin, a hardly less common condition was encountered in the existence of displacements about their margins. It was not always taken into account that upon the margins only, where the rock surfaces are well exposed would it be easy, or in fact possible, to prove the existence of dislocations even where present, and too much stress has perhaps in many cases been laid upon the strictly marginal character of the desert displacements. The inevitable result has been that the depressions were rather generally ascribed to profound tectonic movements in which the floors of the basins represent depressed orographic blocks deeply covered by alluvial deposits derived from the surrounding plateau country.

Under the spell of all these ideas deserts have quite generally been pictured as wastes of sand and salt generally lying below the level of the sea. It has been the work of modern explorers to dispel these illusions and to show that the rock desert is, area for area, vastly more important than the waste of sand. According to v. Zittel not more than a ninth of the area of the Great Sahara is sandy desert. Desor supplied a simple classification based upon the terminology of the Arab nomads which though a partial one only, has come into more or less general use.[24] According to him there are: (1) the *plateau desert* or *hamâda* with its rock surface; (2) the *erosion desert* or *Djûf;* and, (3) the *sand desert* or *Erg* (also called *Areg*). To these v. Zittel added a fourth, the *mountain range desert* (Gebirgswüste).[25]

Rôle of Climatic Change.—v. Zittel reached the conclusion that the desert depressions had been produced by the action of running water, being led to this by the indubitable evidence which he discovered of former conditions of higher precipitation, and by the frequent occurrence of now dry water courses or wadis. That deserts may have their origin in atmospheric rather than in purely lithospheric changes is now generally recognized, and this conclusion of v. Zittel though in error in some respects, marked an important advance over existing views in his time. The origin of the present day desert depressions is thus inseparably connected with the question of changes of climate since the last ice age, and the almost world-

[24] E. Desor, Le Sahara, ses differents types de deserts et d'oasis, *Bull. Soc. Sci. Nat. de Neüchatel*, 1864, also Die Sahara, Basel, 1871, pp. 4-25.

[25] K. v. Zittel, l.c., p. 7. To these should now be added the *gravel desert* due to the armoring process, the *salt desert* of which Central Lop is an example, and also the *clay desert*.

wide evidence which has been discovered of a higher precipitation during Pleistocene times has led many to follow the lead of v. Zittel and to ascribe the erosion of the depressions to river action during a pluvial period.

An adequate idea of the important effects of climatic change is only seldom acquired owing to the fact that the changes are so slow as not to be impressive. In a relatively humid country like Europe the effects of increased desiccation are not strikingly brought out unless the accounts be removed in time by long intervals. A comparison of the history of the Roman conquests beyond the Alps with a statement of present conditions is, however, most illuminating.

There is, it would seem, a critical stage in the desiccating process, at which the springs suddenly fail and the lack of rain prevents seeds from germinating. Simultaneously the animal life is either driven away or perishes upon the ground. The recent arrival of this critical stage of desiccation in the Waterberg province of German Southeast Africa, has been most vividly portrayed by a keen observer upon the ground.[26]

Similar but less striking evidences of rapidly increasing desiccation have been supplied from Northern Africa.[27]

Deflation and Consequent Excavation.—Yet except in so far as land barriers have been erected through tectonic movements or as rivers have flowed out to the sea through the ramparts which surround existing deserts, it is difficult to see how running water, be it ever so vigorous in its action, can have played any other than a secondary rôle in the formation of the desert depressions. It may, indeed, bring down the rock material from the higher to the lower levels and spread it in a manner suited to its further lifting and removal by another agent; but since it must always transfer from higher to lower levels, its part in removing material from an inclosed basin must always be nil. An agent competent to remove rock material from the basin and so accomplish its excavation must, quite unlike running water, be able to transport from *lower to higher* levels. The only available agent known to have this property and not excluded by the evidence is the wind, which in desert regions attains a force quite unparalleled within temperate humid regions.

The credit for clearly appreciating the efficiency of wind as an excavating agent in deserts belongs to Professor Johannes Walther,

[26] Advocate Eugène N. Marias, R. J. P., Reitfontein, Waterberg, Notes on some effects of extreme drought in Waterberg, South Africa, *Agricultural Journal of the Union of South America*, February, 1914, reprinted as publication 2342 of the Smithsonian Report for 1914, pp. 511-522.

[27] Frank R. Cana, The Sahara in 1915, *Geogr. Jour.*, Vol. 46, 1915, pp. 342-346. A. Grund, Die Problema der Geomorphologie am Rande von Trockengebieten, *Sitzungsb. d. Wiener Akad.*, Math.-Naturw. Kl., Vol. 115, 1906, Abt. I, pp. 4-5.

who has devoted a lifetime to the study of desert conditions through extended scientific travels. As early as 1890 in his, "Die Denudation in der Wüste,"[28] he showed the competency of desert winds to lift and remove the rock debris prepared for it by the peculiarly effective processes of desert disintegration and decomposition. To this lifting and transporting quality of the wind Walther gave the name *deflation,* and he urged its efficiency as an excavating agent with even greater force in 1900 and again in 1912 in his now classic work upon desert conditions.[29] To his main conclusion he had been led by the studies of Baron von Richtofen upon the great loess deposits of China,[30] which if truly wind deposited, as von Richtofen believed, required that the fine rock material must somewhere have been lifted with the inevitable consequence of hollowed surfaces or depressions.

The effectiveness of Walther's argument consisted in showing that the deserts, whether hamada, Djûf or Erg, are in the main *Abflusslose,* or have interior drainage, and that the wind not only actually raises and transports both sand and dust, but that the latter passes out of the desert in large quantities. This latter argument received strong support in the classic work of Thoulet upon the deep sea deposits, since this showed that the mineral constituents which were found mingled with the organic lime oozes of the ocean, correspond well with the material which is raised and transported in dust storms.[31] From extended measurements made by Udden the size of these particles is found to be generally less than 0.1 mm. in diameter.[32]

The "trades dust" over the Atlantic Ocean west of the Sahara Desert.—In the tenth century the portion of the Atlantic which lies between the Canary and the Cape Verde Islands, or that lying to the west of the Sahara Desert, was known as *mare tenebrosum,* for the reason that the sky was there so often darkened by dust ("Trades dust"). The easterly trades of the region would clearly indicate the origin of the dust in winds blowing out to sea from the great African Desert. This idea was, however, combatted by Ehrenberg upon the erroneous suppositions that the Sahara sands are white and that the

[28] Johannes Walther, *Abh. d. k. säch. Gesellsch. d. Wiss.,* vol. 16, 1890.

[29] Das Gesetz der Wüstenbildung, Reimer, Berlin, 1900, pp. 175, figs. 50. New Edition entirely rewritten published by Quelle und Meier, Leipsic, 1912, pp. 342, figs. 147.

[30] F. von Richtofen, China, Ergebnisse eigene Reisen und darauf gegründeten Studien, Berlin, 1877, vol. 1, pp. 56-125. On the Mode of Origin of the Loess, *Geol. Mag.,* Dec. 11, vol. 9, 1882, pp. 293-305.

[31] M. J. Thoulet, Analyse d'une poussière éolienne et considérations génerales relatives a l'influence de la deflation sur la constitution lithologique du sol océanique, *Ann de l'Institut Oceanographique,* Paris, III, fasc., 2.

[32] J. A. Udden, Erosion, Transportation, and Sedimentation performed by the Atmosphere, *Jour. Geol.,* vol. 2, 1894, pp. 318-331.

winds of the region blow in the contrary direction. The proof that dust over this portion of the Atlantic is in reality derived from the Sahara region has been clearly established by Hellman upon both meteorological and geological grounds.[33]

The Beginning of a Change in American Opinion.—It cannot be claimed that Walther's views, though so convincingly presented and supported by such a wealth of observation, brought any early change in the prevalent notions respecting the origin of desert depressions. In America, where large monographs had been published upon the geology of the vast interior basins, the influence of the wind as an excavating agent had been entirely overlooked. Gilbert in a carefully guarded statement covering a few pages only, has quite recently suggested that certain hollows occupied by small lakes within the Great Plains area lying to the east of the Rockies, may possibly have had their origin in lifting and transportation[34] of loose materials by the wind. (The greater vegetation of American as opposed to Old World deserts may perhaps in part account for some difference in viewpoint.)

These small depressions are, however, more to be compared with those which are so common a feature of the Karroo and Kalahari in Africa, which as Passarge has shown, while somewhat diverse in their origin, have in all probability arisen through wind action assisted by the movements of the vast herds of large animals which inhabit the region.[35] A far more important paper dealing with the subject of excavation within the American desert regions, is that of Cross, who shows that soils in the mountains of Colorado are probably eolian in origin and derived from the plateau country to the westward. After describing the obvious large measure of deflation in portions of Utah, he concludes that the effective degrading power of the wind has not been fully appreciated by those who have studied the desert regions of the west.[36]

[33] G. Hellman, Ueber die auf dem Atlantischen Ozean in der Höhe der Kapverdischen Inseln haüfig vorkommenden Staübfälle, *Monatesber. Berl. Akad. Wiss.*, 1878, pp. 364-403. Also, Ueber die Herkunft der Staübfälle im "Dunkelmeer," Sitzungsber. kgl. preuss. *Akad. Wissensch.*, vol. 14, 1913, pp. 272-282.

[34] G. K. Gilbert, Lake Basins created by Wind Erosion, *Jour. Geol.*, vol. 3, 1895, pp. 47-49.

[35] S. Passarge, Die pfannenförmigen Hohlformen der südafrikanischen Steppen, *Pet. Mit.*, 57, 1911, II, pp. 57-61, 130,135.

[36] Whitman Cross, Wind Erosion in the Plateau Country, *Bull. Geol. Soc. Am.*, vol. 19, 1908, pp. 53-62, pls. 3-4.

It is probably not well known that Professor Walther as long ago as 1892 drew attention to the effect of wind erosion in the American Deserts (J. Walther, Die nordamerikanischen Wüsten, *Verh. Gesell. f. Erdkunde z. Berlin*, vol. 19, 1892, pp. 1-14 (in separate) Also, The North American Deserts, *Nat. Geog. Mag.*, vol. 4, 1892, pp. 163-176; and A comparison of the deserts of North America with those of North Africa and northern India, *Science*, vol. 19, 1892, p. 158.

Island Mountains as Erosion Residuals.—Fourteen years after the appearance of the "Denudation in the Desert" the same general explanation of the origin of desert depressions through wind erosion was independently brought forward by Passarge with emphasis upon new and important considerations, all based upon extended personal studies within the great deserts of South Central Africa.[37] "The island mountain landscapes," wrote Passarge, "consist of wide plains, actual plains and not flat hilly country, out of which individual mountains rise like islands from the ocean." As described by Passarge from Bechuana Land, the island mountains may be mere knolls or they may be high mountain masses thousands of meters in altitude, but always the floor of the plain meets the steep slope of the islands without any perceptible intermediate gradations of curvature. These island mountains Passarge found to consist uniformly of granite or of other massive and relatively resistant rock, whereas the rock of the surrounding desert floor was sandstone, clay, schist, etc., but in any case softer rocks or those which by reason of lamination planes or fissures were more easily eroded. It thus appeared that the island hills were the unreduced residuals of a denuded area, with the main surface of denudation a featureless plain quite independent of the dip of the strata underlying it. (See author's examples in Pl. XXVI.)

The Rock Floor of the Desert Plain.—As already stated Passarge found the agent of denudation to be the wind, and to meet the objection that there was no obvious cause for the leveling of the plain, he called in the infrequent rains, which according to his view tended to fill in the depressions which were hollowed out by the wind.

The Swedish explorer of Central Asia, Dr. Sven Hedin, in discussing the origin of the Tarim basin, has likewise held the view that water deposition has counteracted a supposed hollowing effect of the wind. Thus he says:

"Theoretically a regular and powerful atmospheric current, blowing across a region in which it does not deposit the drift sand it carries with it, but only excavates, is indeed able to produce a considerable depression. But in the Desert of Lop this result is counteracted by the quantities of water which fill the deepest parts of the basin with solid material, and bring them up *au niveau* with the country adjacent. What therefore during a certain period has been gained through the erosion of the wind, is lost again by the deposition, through the assistance of the water, of sand and silt. Precisely the same amount of solid material as is carried away in one place is accumulated in

[37] Siegfried Passarge, Die Inselberglandschaft im tropischen Afrika, *Naturw. Wochenschrift*, N. F., vol. 3, 1904, pp. 657-665. Rumpfflächen und Inselberge, *Zeitsch. d. deutsch. Geol. Gesellsch.*, vol. 56, 1904, pp. 193-215. Die Kalihari, Reimer, Berlin, 1904, pp. 822 and atlas.

another, the result being a flat alluvial expanse instead of a conchoidal depression.[38]

It is evident, however, that the main erosion of the Tarim basin, if it is to be ascribed to wind erosion, has not been accomplished under the present but under former different conditions of climate which the researches of Huntington[39] show have existed in the past and will again recur. Hedin, who has appreciated this fact, says:

"When the migratory lake of Lop-Nor shall finally have disappeared, and the extreme tentacle of the Tarim shall have died away in the sand higher up its course than it does now, the wind will then be able to excavate the desert of Lop unchecked, producing a deep depression, the center of a never ending aridity."[40]

The appearance of Passarge's monographs upon the deserts of South Africa so impressed Professor Davis, who had developed his geographic cycle without reference to the vast arid regions, that in his "The Geographic Cycle in an Arid Climate"[41] he adopted Passarge's ideas concerning the formation of level-floored basins under arid conditions through the action of wind erosion supplemented by running water; the level of the floor having no necessary relation to any base-level as this term is understood in its application to humid regions. Mawson has supplied other examples from the Australian deserts.[42]

The traditional view which has held that desert basins are tectonic in their origin—that the depression is the result of the settlement of one or more orographic blocks—naturally led up to the view that the evenness of the desert floor was always to be explained through alluviation from surrounding heights. Being thus a broad surface of deposition, the surface of the rock was assumed to be covered to considerable depths. Passarge's discovery that the floor of the plain was often of rock and that the surface deposits were in any case comparatively thin, was, however, not an isolated one and has been confirmed by similar observations in other desert regions, some of which antedate by many years the date of Passarge's first monograph.[43] McGee, who had been

[38] Sven Hedin, Scientific Results of a Journey in Central Asia, 1899-1902, vol. 2, 1905, p. 460.

[39] Ellsworth Huntington, Lop-Nor—A Chinese Lake, *Bull. Am. Geogr. Soc.*, vol. 39, 1907, pp. 65-77, 137-146. The Pulse of Asia, New York, 1907, pp. 415, maps and plates. The Rivers of Chinese Turkestan and the Desiccation of Asia, *Geogr. Jour.*, vol. 28, 1906, pp. 352-367.

[40] Hedin, l.c., p. 461.

[41] W. M. Davis, *Jour. Geol.*, vol. 13, 1905, pp. 381-407.

[42] Douglas Mawson, Geological investigations in the Broken Hill Area. *Mem. Roy. Soc. So. Australia*, vol. 11, 1912, pp. 224-223, pl. VI. 2.

[43] W. J. McGee and W. D. Johnson, Seriland, *Nat. Geogr. Mag.*, vol. 7, 1896, pp. 127-128. W. J. McGee, Sheetflood Erosion, *Bull. Geol. Soc. Am.*, vol. 8, p. 91, C. R. Keyes, Geological Structure of New Mexican Bolson Plains, *Am. Jour. Sci.*, vol. 165, 1903, pp. 207-210.

forced by this discovery in the deserts of southwestern New Mexico and Northern Mexico to abandon the idea of an alluviated plain, sought to explain the even surface of the rock by sheetflood erosion, though this could obviously not apply to all parts of the desert floor.

The Pebble Armor of the Desert. It was Penck who first suggested the name of armoring (*Panzerung*) of the desert as a result of lighter and finer materials being carried away through deflation or wind transportation, while coarser or heavier fragments are left behind.[44] It was Walther, however, who by full descriptions and many excellent photographs showed the great importance of the process over vast areas in the arid regions.[45] In by far the larger number of instances "pebbles" composing the armor are harder nodules such as fossils, flints or concretions which are derived as a residual from higher beds that have been disintegrated and removed by the wind. Such thin veneers over rock have no doubt in many instances been taken for the surface portions of thick deposits of sediment. (See Pl. XVII.)

Planorasion. Though the desert floor approximates to a plane surface, it is by no means true that it is always level. This fact has been brought prominently forward by Dr. C. R. Keyes,[46] though his statements have been sharply challenged, and the records of well borings seem to show that the rock floor of desert basins is less common a feature in the Great Basin region than Keyes has claimed. Working in conjunction with the processes of desert disintegration the wind acts as an abrading and eroding agent which, unlike running water, works up-hill. This process, termed by Keyes *planorasion,* in the early stages of its action may grade a slope as steep as 4% (claimed to be not uncommon along the lines of railway crossing the western deserts of the United States), but this is probably near the limit of steepness of slope which planorasion can erode as a plane.[47] Sheet-

[44] A. Penck, Die Morphologie der Wüsten, Geogr. Zeitsch., vol. 15, 1909, p. 551. The result is a "gravel" desert. See ante, p. 42.

[45] Das Gesetz der Wüstenbildung, Edition of 1912, pp. 186-195.

[46] C. R. Keyes, Geological Structure of New Mexican Bolson Plains, *Am. Jour. Sci.*, vol. 165, 1903, pp. 207-210. Rock-Floor of Intermont Plains of the Arid Region, *Bull. Geol. Soc. Am.*, vol. 19, 1908, pp. 63-92, pl. 5. Geologic Processes and Geographic Products of the Arid Region, ibid., pp. 570-575, pls. 38-41. Erosional Origin of the Great Basin Ranges, *Jour. Geol.*, vol. 17, 1909, pp. 31-37. Certain Features of Eolic Gradation, Cong. Géol. Intern. 12me Sess., Canada, 1913, pp. 1-5 (advance copy). These views of Dr. Keyes have been contested especially by Tolman (*Jour. Geol.*, vol. 17, 1909, pp. 136-163) and Tight (*Am. Geol.*, vol. 36, 1905, pp. 271-284) on the ground that desert floors are not generally of rock but are often overlain by considerable deposits of alluviated material.

[47] Barron has described from the Arabian Desert a distinctly inclined surface of Eolian planation which bevels the strata (T. Barron, The Topography and Geology of the District between Cairo and Suez, Surv. Dept. Egypt, 1907, pp. 19, 115-116).

flood erosion, according to Keyes, instead of producing the planed surface of the desert floor is rather a direct consequence of it. The levelled floors of the South African deserts which have been described by Passarge, with little doubt illustrate later stages in the operation of the process of planorasion; and it is doubtful if the aggradation by running water invoked by Passarge is at all essential in order to account for the level surface. Moreover, as Keyes shows by examples, the wind is a far more potent agent in evening out by deposition any hollows of the surface than is running water.

The Possible Effect of Caliche Armor.—Woodward in describing the great flat floors in the arid region of Western Australia, has shown that truncated schists are either at or near the surface, the truncation in his view being due to wind erosion and the level determined by the level of ground water sufficiently near the surface for capillary attraction to conduct the water to it and hold the material against the action of the wind.[48] Jutson who has since investigated the same region, has supplied an interesting explanation of the formation of these plains.[49] The underground water in being drawn up to the surface brings with it dissolved mineral matter which is deposited in a surface layer to form a hard protective cap, which may vary in thickness from a few inches to a few feet. Jutson's idea seems to be that the originally flattish surface provided with protective armor of this sort becomes broken through locally by gully formations at the time of infrequent but violent desert rains, and that thereafter the cap is progressively undermined by deflation so that in time a new plain develops at the new base level which eventually becomes armored as was the first.

Two recent papers which have revived with ingenious elaborations the older theory of formation of desert floors wholly as a result of water erosion and alluviation, while ignoring the deflation process, are those of Paige[50] and Lawson.[51]

Relative Importance of Deflation and Alluviation.—Whatever may be the relative measures of deflation and alluviation within desert basins—and we are still very far from a definitive settlement of the question—the dust clouds so generally to be observed upon the leeward margins of the basins and the eolian soils outside, show only too

[48] H. P. Woodward, The dry lakes of Western Australia, *Geol. Mag.*, (4) Vol. IV, 1897, pp. 363-366.

[49] J. T. Jutson, An outline of the physiographical geology of Western Australia, Bull. 61, Western Australia Geological Survey, 1914, pp. 142-158.

[50] Sidney Paige, Rock-cut surfaces in the desert ranges, *Jour. Geol.*, Vol. 20, 1912, pp. 442-450.

[51] A. C. Lawson, The epigene profiles of the desert, *Univ. of Calif. Pubs., Dept. of Geol.*, Vol. IX, No. 3, 1915, pp. 23-48, pls. 1-2.

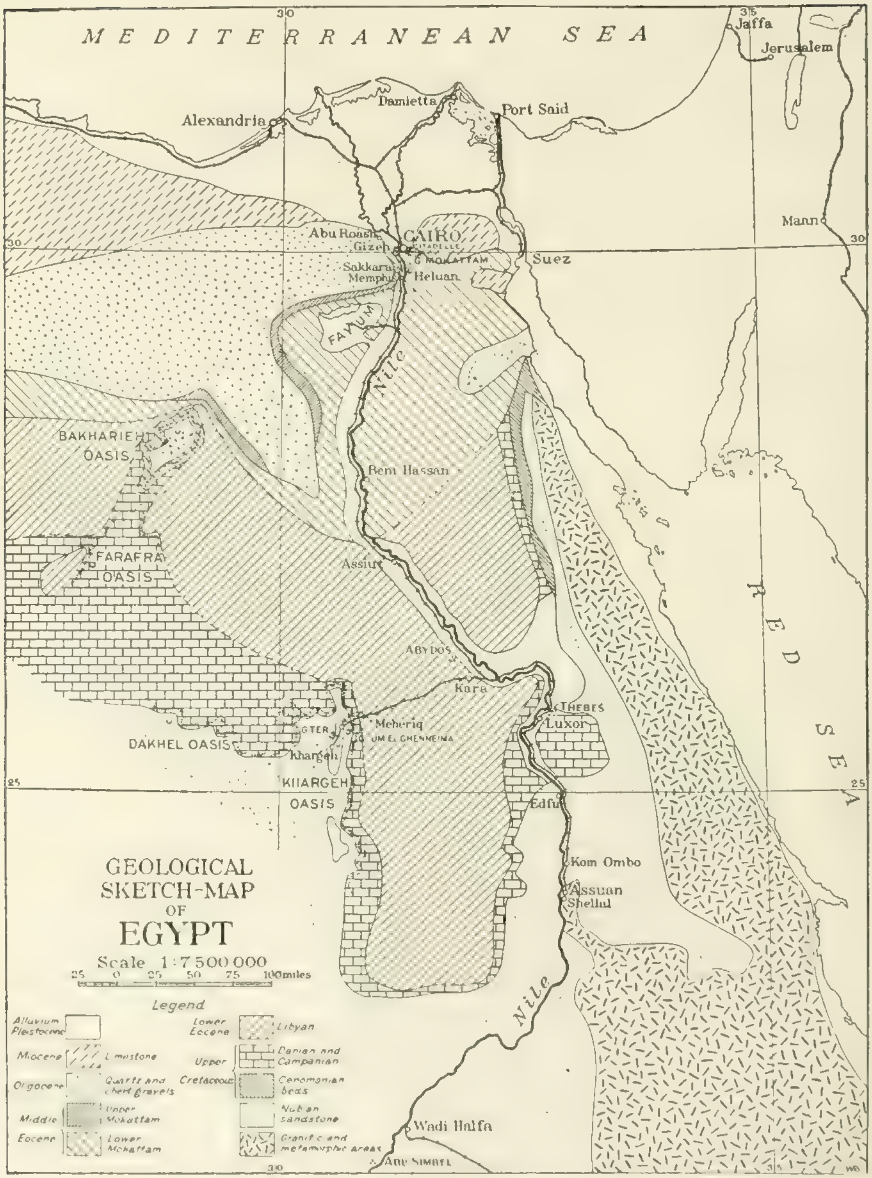


FIG. 4—Geological Sketch-Map of Egypt (after Hume).

clearly that if the floors have been raised through alluviation, as has so generally been assumed, the measure of this work must have been many times greater than that indicated by the thickness of the floor deposits themselves, a fact amply confirmed by the coarseness of the alluviated materials.

An apt illustration of what is meant is furnished by the Oriental

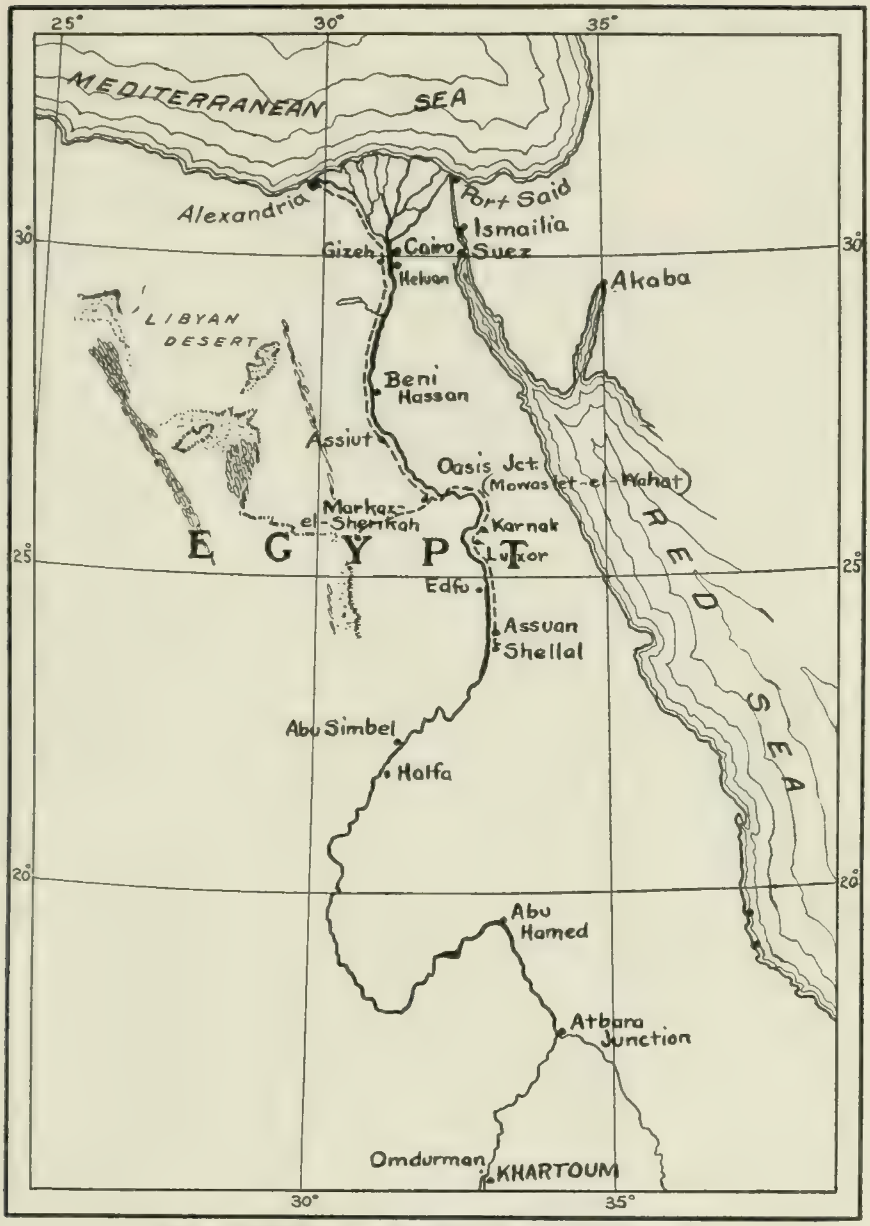


FIG. 5—Sketch-Map of Egypt and the Libyan Desert

threshing process, where the bulk of the material—the chaff—is carried away by the winds, leaving behind upon the threshing floor a selected residue only, and likewise of the heavier and coarser materials. In the case of deserts, this residue having much of it been brought down from the surrounding highlands through the process of alluviation,

easily gives the impression that the desert floor has been raised by alluviation, though it may have been actually lowered through deflation.

THE OASIS DEPRESSIONS OF THE LIBYAN DESERT.—*Physiographic Simplicity of the Libyan Desert.*—Whereas the Arabian Desert lying eastward from the Nile toward the Red Sea presents some variety of topographic feature and a number of strongly developed valleys tributary to that river, the Libyan Desert to the westward of the Nile is a broad featureless plateau or *hamada*,[52] which rises nearly 1,000 feet above the bottom of the Nile rift, a plateau which is locally interrupted by more or less flat-bottomed basin-like depressions obviously excavated out of the hamada. These basins are relatively few in number and often are of quite moderate dimensions compared to those of the plateau as a whole. One of them, however, the Great or Kharga Oasis, covers a number of square degrees. The other oasis depressions are quite largely included in the rectangle bounded by the meridians of twenty-five degrees and thirty degrees east longitude and by the parallels of twenty-five degrees and thirty degrees north latitude (figs. 4 and 5). They are known as the Dakhla, Farafra, Baharia, and Siwa Oasis, the latter far to the northwestward of the others and correspondingly difficult of access by travelers (fig. 6). To those mentioned should perhaps be added the Fayûm, which is connected with the Nile rift, the Wadi Natron, and Araj. The depths of each of these basins and the elevations measured from mean sea level of the rim and floor have been given as follows:

Oasis.	Elevation of Floor in Meters	Elevation of Rim in Meters	Depth of Basin in Meters
Araj	—70	+120	190
Fayûm	—44	+340	384
Siwa	—25		
Wadi Natron	—28	+205	207
Kharga	—18	+448	466
Dakhla	+58	+485	391
Farafra	+26	+320	294
Lake Sitra	—25		
Baharia	+134	+311	177

With the exception of these basins the Libyan hamada may be considered the most arid area upon the globe, since it is almost absolutely devoid of water. The hamada is actually little explored except along the established caravan routes connecting the basins. These basins themselves have, however, each been investigated and made the subject

[52] George Steindorff, Durch die Libysche Wüste zur Almonsoase. Land und Leute Monographien zur Erdkunde. Velhagen und Klasing. Leipzig, 1904.

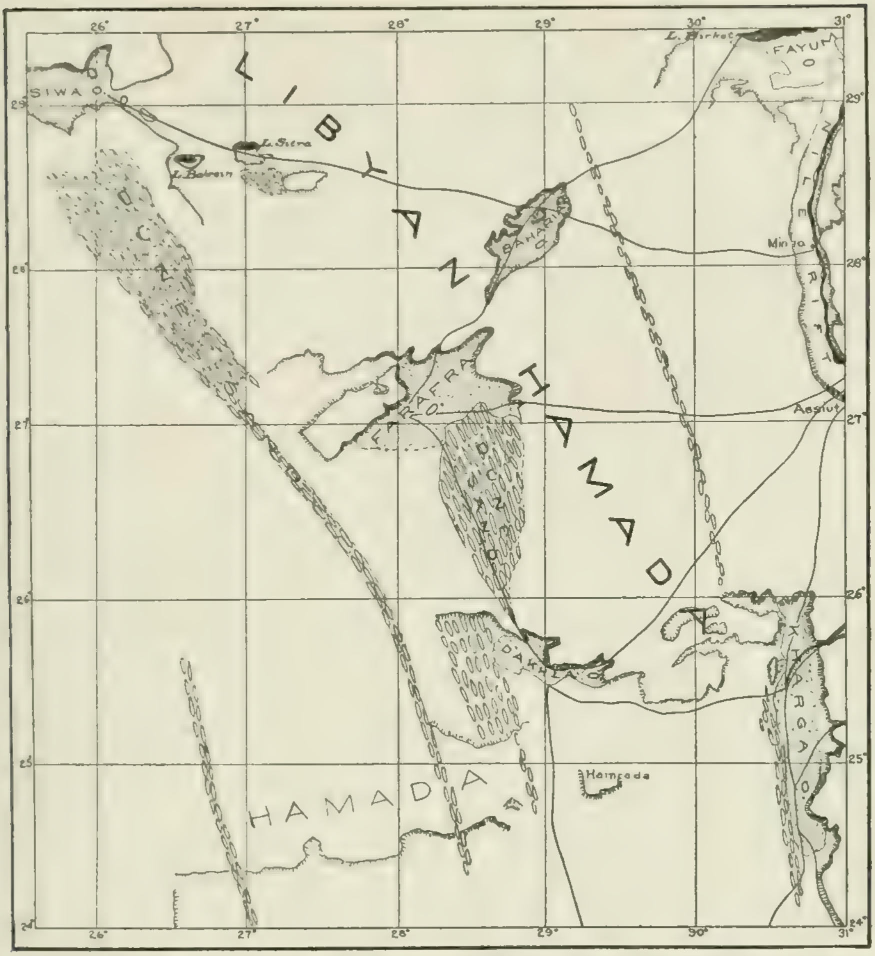


Fig. 6. Sketch map showing the depressions in the Libyan hamada, based on the map by the Egyptian Survey

of a special report, the Siwa oasis by the Public Works Ministry,[53] and the others by the Egyptian Survey Department.[54]

A crude attempt to present in vertical section the shape and pro-

[53] Report on Siwa Oasis, 1900.

[54] Kharga Oasis, its Topography and Geology, by John Ball, 1900.

Dakhla Oasis, its Topography and Geology, by H. J. L. Beadnell, 1901.

Farafra Oasis, its Topography and Geology, by H. J. L. Beadnell, 1901.

Baharia Oasis, its Topography and Geology, by J. Ball and H. J. L. Beadnell, 1903.

See also, Topography and Geology of the Fayûm, by H. J. L. Beadnell, 1903; An Egyptian Oasis (Kharga), London, 1909, pp. 248; Ellsworth Huntington, The Libyan Oasis of Kharga, *Bull. Am. Geogr. Soc.*, vol. 42, 1910, pp. 641-661; Wm. H. Hobbs, A Pilgrimage in Northwestern Africa with Studies of Desert Conditions, *Geogr. Rev.*, Vol. 3, 1917, pp. 337-365.

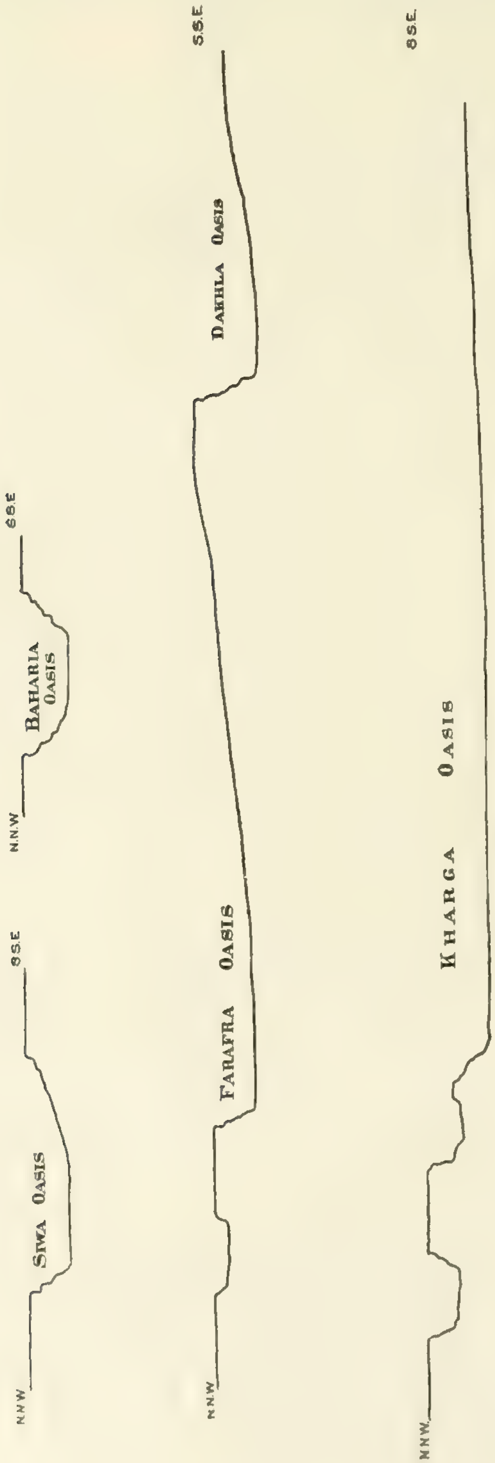


FIG. 7.—Rough sections across desert depressions

portions of the basins, has been made in fig. 7, with gross exaggeration of the vertical scale. From these and from the map it will be apparent that the northerly and northwesterly margins of the depressions when compared to the opposite walls are remarkably steep, and that in the larger depressions the basins deepen gradually in the direction of these margins. This fact is believed to be one of significance. The Government map indicates further that heavy sand dunes have formed upon the hamada on the south of the smaller depressions when a southern wall is indicated, and that the sand dunes starting from the southern margins of the depressions trail off to leeward to distances many times the diameter of the basins themselves. Of the smaller basins the floors are notably flat and are generally formed of the upper water-bearing layer of the Nubian Sandstone.

Origin of the Depressions.—All the physiographic peculiarities of the basins appear to indicate their origin through the process of deflation, that is to say, to the lifting and transporting action of the wind, which here blows throughout the year from directions included within an extremely narrow sector a few degrees only to the west of north. It is highly probable from the arrangement of sand dunes that farther to the westward the constant winds approach more nearly to the northwesterly direction. The origin of the depressions through the agency of running water is inconceivable, for the reason that water has not the power when free flowing to transport material from lower to higher levels, here absolutely essential in order to accomplish the excavation.

Walther has already invoked the deflation theory of origin to explain the depressions, without, however, making use of the evidence which is afforded by the official map,[55] here printed in outline. Says Walther, "Yonder the hollows, here the areas of deposition are filling, and between both the wind bride marches. Whoever recognizes this connection and has followed it searchingly, must come to the conclusion that the deflation of the wind is the determining factor in the fashioning of the desert relief."

What gives to the Libyan desert its special fitness as an area within which the problem of the sculpturing agent may be decisively solved, is above all its excessive aridity and the fortuitous circumstance of an essential constancy in flat dip of rock beds and in wind direction. The criteria which seem to be decisive in the solution, are (1) the orientation of the unsymmetrical basins with regard to the wind direction, (2) the location of the sand and dust accumulations to the leeward of the basins, and (3) the halting of the process of excavation in the

55 Johannes Walther, The various articles of earlier years are summarized in "Das Gesetz der Wüstenbildung" 2te. Aufl., 1912; General discussion, pp. 164-179, special application to the Libyan depression, pp. 205-211.

larger and maturer basins so soon as a water bearing formation has been laid bare. (Nubian Sandstone).

Orientation of the Basins with Reference to Wind Direction.—The several basins appear to represent varying degrees of maturity in the excavating process, the smaller and shallower ones being in general the younger. Such are Siwa, Baharia and the diminutive depressions of Araj, Lake Sitra and Lake Bahrein. Farafra and Dakhla oases obviously represent more mature stages, while Kharga with its large dimensions and pronounced asymmetry, is by far the most mature of all.

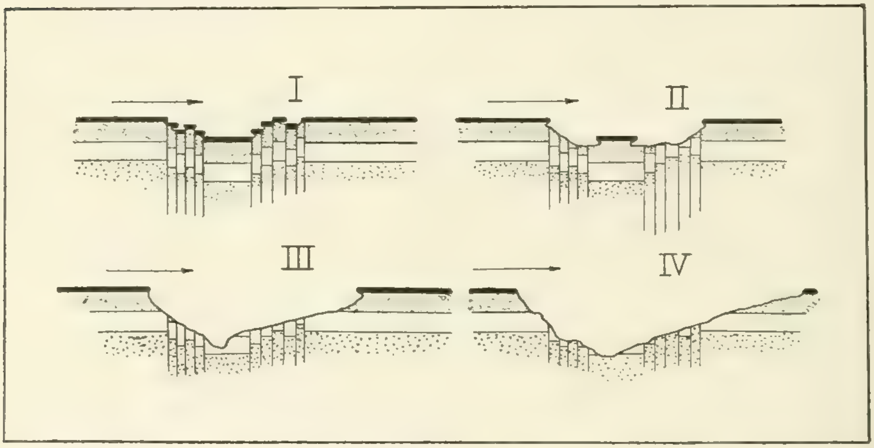


Fig. 8.—Stages in the excavation of desert depressions by deflation initiated by local faulting

Passing over for the present the cause of the localization of the basins, we note that the smaller depressions are bounded throughout by steep walls, though these are much more precipitous and quite generally inaccessible upon the windward (north northwesterly) side. When the shaping of the basin is ascribed to deflation aided by the flying sand, the steep wall upon the windward side is readily explained by the eddy which is always turned under and backward above each hollow of the ground. Such an eddy would result in sapping and should produce the steep cliffs characteristic of that process in a wide range of geological phenomena. No such eddy should develop upon the leeward margin of the depression, where abrasion and deflation of more normal type would take its place and develop a backward sloping surface (with regard to wind), which would grow flatter as the area of the basin is enlarged.

Significant Position of the Coarser Excavated Material.—The areas of dune sand which lie to the leeward of the Siwa and Farafra de-

pressions, and the similar small dune area connected with Lake Sitra, point strongly to the derivation of this sand from the excavation of those basins with which they are geographically connected. The long, narrow trail of dunes strung out upon the hamada toward the Nile valley from the central group of depressions, with little doubt has its beginning in an unknown basin lying within the great unexplored area to the westward of the Fayûm. Another unknown basin probably lies to the westward of the Dakhla or Farafra oasis.

Deposition of the Loess as the Cotton Soil of the Sudan.—In addition to the sand which moves along the desert surface by saltation and is carried to very moderate heights only, the finer dust often reaches to considerable altitudes. Traveling with a relatively high velocity, this finer material is not permanently halted in its course until it encounters a moist surface. In the region under consideration such a moist surface is first met with where the tropical rains make their greatest advance to the northward, a limit which is reached some 150 miles to the northward of Khartoum. This loess deposit is, according to Mr. G. W. Grabham, the Geologist to the Sudan Government, of a thickness increasing to the southward and sometimes as much as one hundred feet in depth. It is the soil found suitable for cotton growing upon irrigation.[56] One of the dust storms arriving at Khartoum from across the Blue Nile to the northward is represented in Plate XXIIa.

Arrest of the Downward Excavating Process in the Basins When the Water-Bearing Sandstone Has Been Laid Bare.—The deflation process is arrested when rock layers containing water are encountered. The series of rocks represented, range from the Nubian Sandstone, which rests directly upon granite and metamorphic rocks, up through Upper Cretaceous and Tertiary beds to terminate in a limestone of Miocene Age. As all are gently tilted toward the northward, the capping of the Hamada over a large part of the Libyan Desert is the Lower Eocene or Libyan limestone (fig. 8). The depressions are generally excavated out of this superior formation, the Upper Cretaceous beds, and a considerable thickness of the Nubian Sandstone, until a water-bearing layer is reached.

Cause of Localization of the Desert Depressions.—In the writer's belief the most probable cause of the localization of the basins, is to be found in local faulting amounting in the aggregate to some hundreds of feet, though distributed through a considerable zone and represented by small individual displacements upon each fault plane—a cause

[56] G. W. Grabham, Wells of the Northeastern Soudan, *Geol. Mag., N. S.,* Dec. V. vol. 6, 1909, pp. 265-267, fig. 1. See also Sir William Willcocks, Egypt Fifty Years Hence, address delivered at a meeting of the Khedivial Geographical Society, Cairo, March 15, 1902. Printed under title, The Restoration of the Ancient Irrigation Works on the Tigris River, Cairo, 1903, pp. 43-71.

which may likewise be appealed to for explanation of the rift of the Nile itself. Eduard Suess[57] was one of the first to draw attention to the importance of meridianal fractures in fixing the course of the Nile rift. Passarge[58] has since supplied a much more comprehensive treatment of the tectonic lines of the African Continent. The reports of Barron and Hume,[59] Ball,[60] and Hume,[61] covering the Arabian Desert and the Desert of Sinai, show how for these areas the course of each wadi is controlled by dislocations. This control by fractures is given expression by the official maps in numerous localities.

In ascending from the Nile rift along the wadi from Qara by the railway to Kharga Oasis, the existence of a layer of large concretions permits one to note the presence of hundreds of faults of small displacement (usually from one to two feet) with sub-equal space intervals.

Within the Kharga Oasis Ball has called attention to the presence of faults. In summarizing he says, "From the foregoing brief discussion of the tectonics of the oasis, it will be apparent that the whole area has undergone disturbance resulting in folding and faulting; and since the faults affect the highest rock on the plateau, it is clear that they took place since the deposition of all the strata which now occur in the oasis."[62]

It is not necessary that the disturbances of the strata which have been responsible for the excavation of the oases within the Libyan Desert, should be essentially different from those which the writer observed especially upon the eastern margin of the hamada toward the Nile rift. In order to understand how small displacements can initiate excavation within the hamada, it is necessary to take into account the thin capping of "glass hard" limestone which is here underlain by a softer limestone with interbedded layers of marl and clay, the entire series ranging from 76 to 136 meters in thickness. This is in turn underlain by the gray and green clays of the Esna Shales. The thin but resistant mesa cap is but slowly worn away by the desert sand blasts, and is polished until it glares in the sun like burnished metal. Once lifted by local faulting the cutting sand attacks

57 E. Suess, Die Brüche des östlichen Afrika. Denksch. *Wiener Akad., Math. Naturw. Kl.*, vol. 58, 1891, pp. 555-584.

58 S. Passarge, Die Kalihari, Berlin, 1904, pp. 79-80.

59 T. Barron and W. F. Hume, Topography and Geology of the Eastern Desert (Central Portion), 1902.

60 John Ball, A Description of the First or Aswan Cataract of the Nile, 1907. See also, H. J. L. Beadnell, The Cretaceous Region of Abu Roash near the Pyramids of Giza, 1902.

61 W. F. Hume, The Topography and Geology of the Peninsula of Sinai (Southeast Portion), Surv. Dept. Egypt, 1906, pp. 29-37.

62 John Ball, Kharga Oasis, Its Topography and Geology, Surv. Dept. Egypt, 1900, pp. 95-100; See also J. H. L. Beadnell, An Egyptian Oasis, pp. 53-54.

the soft underlying shales, a process which may be observed in operation upon the eastern scarp of the Kharga Basin, for when once exposed the soft underlying shales are removed by deflation, thus sapping the limestone cap.[63]

The stages likely to develop in the excavation of a desert basin as the results of such conditions, are set forth in Fig. 8, in which stage III is represented to-day by the small oases Siwa and Baharia, and stage IV by the more mature types Farafra, Dakhla, and Kharga. We have chosen to represent marginal dislocations about a small depression, but the evolution can just as well be accomplished wherever small local disturbances are found, the one essential being that the sand blast be allowed to make its attack upon the soft shales beneath the hard limestone capping. Once laid bare, this loosely coherent material requires no considerable disintegration, but is lifted by the wind and carried away to leeward. Hume has recognized the importance of this process when once the capping has been removed.[64]

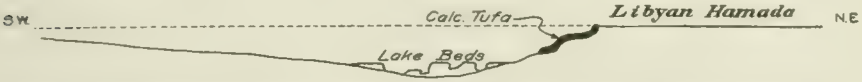


FIG. 9.—Schematic diagram to show position of lake deposits and calcareous tufa in Kharga depression

Former Climatic Strophe of the Libyan Desert.—If the basins within the Libyan Desert are to be regarded as the work of the wind which lifts and removes the material from beneath the hamada capping, and eventually also the disintegrated fragments of the latter; the major portion of the work must have been accomplished, not in the present arid cycle of the region, but in a former period of great aridity, separated from the present by a humid period. The evidence of this humid strophe is furnished by the calcareous tufa on the eastern scarp of the Kharga Basin and by other similar formations of cataract origin nearer the Nile, and also by extensive lake deposits, the remnants of which are still to be found in the bottom of the Kharga depression. These remnants of lake deposits have by the constant northerly winds been carved into asymmetrical north-south ridges (Fig. 9). The lake in which they were laid down must have had according to Beadnell at one time a depth of some 85 meters, and for a considerable period a depth of 70 meters. The deposits contain fresh water shells, bones of the ox and of either a horse, donkey or zebra, as well as pottery dating from the Graeco-Roman period.[65] The deposits of tufa which occur on the capping of the hamada and extend down the Refûf Pass

[63] Ball, l.c., p. 95.

[64] W. F Hume, The South West Desert of Egypt.

[65] Beadnell, An Egyptian Oasis, ch. viii.

into the oasis, inclose beside numerous fresh water shells, casts of leaves of deciduous trees, among them those of the oak, as was first pointed out by von Zittel.[66] There seems also to be evidence in the dregs in exhumed pottery vessels that the vine was grown in the oasis, evidence which receives support from some of the inscriptions upon monuments in the valley.

Ball's difficulty in explaining the origin of these basins we believe is largely due to his failure to conceive the possibility of alternations of climate within cycles, passing from arid through humid to arid conditions again; a conception that now receives support in many fields and nowhere more than in that of glaciers. Ball says, referring to the tufa deposits;[67]

"As these tufa deposits were formed after the oasis had acquired substantially its present form, we must infer that the main excavating agency in past times cannot have been the sand blast, for this would be irreconcilable with the idea of a then prevalent moist climate.

" It is therefore most likely that the excavation was begun by the action of water, and after this ceased, owing to a total change in the climatic conditions, the work was continued and is being continued by the agency of wind and sand."

This failure to appreciate the alternations of climate (strophes) is, in the belief of the writer, responsible for much misconception among archaeologists and geologists alike. For example, the simple and natural explanation for the abundant big game fauna depicted in the wonderful mural decorations of the Mastabas of Ti and Ptahhotep at Sakkâra on the eastern margin of this desert, is that a wild animal life, not unlike that found to-day in the Uganda to the southward once lived here in a humid climate. We know that a large stream poured its waters over the brink of the hamada into the great oasis, which then held a large fresh water lake. Upon this assumption only is it possible adequately to account for the much larger population and the high degree of civilization which then existed there.[68]

66 Geologie der Libischen Wüste, 1883.

67 l.c., p. 101.

68 Geographical Review, vol. iii, No. 5, May, 1917, p. 344.

MEMOIR OF CLEVELAND ABBE

ALFRED JUDSON HENRY

Cleveland Abbe was the oldest of a family of seven children:

Cleveland	1838	
Walter	1841	
William	1843	Wounded at Gettysburg
Charles	1849	
Robert	1851	
Helen	1853	
Harriet	1855	

of whom all are living save his brother William, who died from the after-effects of the wound received at Gettysburg. Robert became a skillful and famous surgeon of New York; Walter, his favorite brother, was for many years head chemist of the Atlantic White Lead works; and Charles, a skillful inventor, who died in 1917, was for some years an assistant examiner in the U. S. Patent Office.

Cleveland Abbe was faithfully helped and supported throughout the strenuous Seventies and Eighties by his first wife, Frances Neal, and his last years were almost a resurrection for him in the care and love bestowed on him by his second wife, Margaret Percival, of St. Kitts, B. W. I.

He died after a somewhat extended illness at his home in Chevy Chase, Md., October 28, 1916, being almost 78 years of age. His boyhood was spent in New York, with the exception that most of the summers were spent at the old family home near Windham, Conn. He was undoubtedly nearsighted at birth, for he could never see to play ball and spin tops as other boys did, but this nearsightedness was not discovered until he was nearly fourteen, and it was not helped by a Fourth of July experience with a well-charged anvil that seemingly refused to go off until he held his eyes close down over it. He received the charge almost full in his eyes and for a while his sight was despaired of. Probably his nearsightedness predisposed him for reading, of which he was always inordinately fond, though not along the lines prescribed by the school curriculum. During his summers in Windham he should have been helping his grandfather, Moses Cleveland Abbe, run the farm, but he preferred to lie out in the warm July sun and observe and study the clouds floating overhead. At the time this did not create a favorable impression. While a keen observer and reasoner in all the natural sciences, he undoubtedly took most interest at this time in the weather. He was early impressed with the idea that much of the weather knowledge then current was faulty

and this impression was doubtless confirmed upon reading the occasional popular articles which appeared in the daily papers, often contributed by the leaders in meteorological thought of that period.

In the summer of 1858 there appeared in Runkle's Mathematical Monthly the first of a series of classic articles by William Ferrel, entitled "The Motions of Fluids and Solids on the Earth's Surface." Abbe was quick to realize the epoch-making nature of these articles, also that many of the difficulties that had hitherto existed in the generally accepted beliefs had been overcome. It is difficult properly to estimate the influence that the writings of William Ferrel had upon the mind of young Abbe. Fortunately for Meteorology, his mind at that time was in the formative period.

After graduating from the College of the City of New York in 1857, Abbe was engaged in tutoring for a short season: then wishing to continue his studies in astronomy, he studied at Ann Arbor under Brünnow and later at Cambridge under Gould. At the time he went to Cambridge, Dr. Gould was perhaps one of the most active and influential astronomers in the United States. A short time previously he had taken charge of longitude operations in the Coast Survey and it was principally as an aid in that Survey that young Abbe received his first field experience in astronomical work.

In April, 1861, he answered the first call for volunteers to defend the Union:—naturally, since in his veins ran the blood of participators in all the wars of the colonies and all the battles of the Revolution save those of Lexington and Concord. For a few weeks he was tried out at a recruiting camp, but his nearsightedness rendered him helpless without the aid of strong corrective glasses, and he was therefore soon dismissed as not fit for service. This was a severe disappointment to the ardent patriot and the sincere hater of slavery; but he turned to astronomy for consolation. He was with Dr. Gould from 1860 to 1864. The experience thus obtained was doubtless the incentive which took him to Russia, where he remained two years, 1865-1866, as a guest at the Nicholas Central Observatory, Pulkova, near Petrograd.

Returning to the United States in 1867, he served as an aid in the U. S. Naval Observatory until called to Cincinnati as the Director of the Astronomical Observatory at that place. Throughout his career as an astronomer, Abbe never lost his interest in atmospheric phenomena, and indeed we find that the dominant note in his inaugural address as director of the Cincinnati Observatory on May 1, 1868, was the practical results which would flow to the public, as well as to the astronomer, from a system of telegraphic weather reports.

Abbe's career as an active astronomer ended shortly after his acceptance of a responsible position in that science. His career as an active meteorologist began with the successful movement to interest the local

Chamber of Commerce of Cincinnati in a system of telegraphic weather reports.

The story of the establishment of a modest private weather service by the Cincinnati Observatory, in co-operation with the Western Union Telegraph Company has often been told. We will not repeat it here.

Professor Abbe's own personal feelings in the matter is reflected in a letter addressed to his father in New York, which contains the following statement:

"I have started that which the country will not willingly let die."

Less than a year after the first bulletin of the Cincinnati Observatory was issued, the Federal Government, through a congressional resolution under date of February 9, 1870, authorized the creation of a Weather Service, and placed it under the immediate direction of the Signal Service, a part of the military establishment under the War Department, in which it remained until June 30, 1891. On that date the meteorological duties were transferred to a bureau to be known as the Weather Bureau, and the latter was placed in the Department of Agriculture.

Professor Abbe began his duties in the Signal Service on January 3, 1871, as a Professor of Meteorology and Senior Scientific Assistant to the Chief Signal officer. He was continuously on duty from that time until June 4, 1915, when he took a year's furlough. Returning from furlough and being still in ill health he resigned on August 3, 1916, after a little more than 45 years continuous service to the Federal Government.

When Professor Abbe entered the Signal Service in 1871 he was assigned to the preparation of the tri-daily synopsis, probabilities and facts, or what would now be termed the forecasts. As soon, however, as certain army officers attached to the Signal Service as assistants to the Chief Signal Officer, could be trained to the work by Professor Abbe, he was relieved from forecasting duty and was regularly occupied as the senior scientific advisor of the service. His duties, which at that time had not taken concrete form, were later defined and he was assigned to what was at first called the Study Room,—later the Study Division.

Here, for nearly a score of years, Abbe was engaged in the consideration of questions relative to the investigation of meteorological phenomena, standards of measurement, altitudes and tables of reduction of observations; and later there were added to his care, the preparation of a Bibliography of Meteorology (upon which he personally spent much time) and the investigation of thunderstorms and tornadoes. The active work upon the two subjects last named was delegated to others.

In 1886 the Study Division was reorganized and merged with several other divisions into a new division, known as the Review Division.

The new division was to have charge of the preparation of the manuscript of the Monthly Weather Review, the Monthly Meteorological Summary and Review, the International Charts and the tri-daily Meteorological Record. To Professor Abbe was specifically assigned the preparation of a popular "Treatise on Meteorology and Meteorological Instruments" and the completion of the Bibliography of Meteorology. It was the custom at this time for the Army officers and certain of the higher class of civilian employees, including Professor Abbe, to alternate in charge of the various meteorological divisions of the Washington office, including the preparation of the tri-daily probabilities. The Probability Officer, as he was called, also acted as editor of the Monthly Weather Review for the month during which he was responsible for the probabilities—the editorial work, of course, coming in the month after the probability work had been finished. Thus it happened that throughout the military regime there was no single person continuously responsible for the editorial work of the Monthly Weather Review. When the Bureau came under civilian control a Board of Editors was appointed to conduct the Review, but this board was dissolved in July, 1893 and immediately thereafter Professor Abbe was assigned to the editorship, beginning with the number for August, 1893.

Meantime he had been variously occupied, mostly in the Study Division but occasionally, as in 1888, he alternated with others on the forecast work. He also made the forecasts of June 1891, the last month of military control and, finally, he was the official forecaster for August, 1893, which latter period marks the completion of his services as a forecaster.

It was in the capacity of Editor of the Monthly Weather Review that Professor Abbe is best known, and it was in that capacity that he found his most congenial labor. For upward of a score of years he conducted that Journal with marked success, bringing it to its present high standing as the representative meteorological journal of the English-speaking people, through his strong individuality, sincerity of purpose, and high ideals.

In all these forty odd years, Professor Abbe, while carrying on his official duties, never lost an opportunity to urge in public and private the importance of the study in colleges and universities of the fundamental problems of meteorology and in the public schools of the simpler phases of the subject. Nor was he unmindful of the good that would accrue from the study of meteorology to many persons who could not have the advantage of any regular course of instructions. To these, his appeal was to form local clubs or societies for the purpose of investigating problems of local climatology; the relation of local climate to any special crop or other similar investigations.

If I were to indicate that characteristic of his life-work which has

impressed me most, I would unhesitatingly name as first his unbounded enthusiasm for meteorology and his abiding faith in its future. Clearly, therefore, his great work was inspiring in others a measure of that fervent hope for the future that he himself felt. His was not the enthusiasm of a dreamer; he realized full well that results could be obtained only through sustained effort and was himself careful to set an example of industry that might well be imitated by others.

Professor Abbe was modest in his demeanor, almost to a fault. His tastes were of the simplest character. The top of a packing box, to serve as a desk, a plain stool, and a bottle of ink, easily satisfied his demands for office equipment.

A list of the papers of Professor Abbe will doubtless appear elsewhere. The list is a long one and I very much doubt whether it is now possible to prepare a complete one. It was his habit in the later years of his life to undertake more than it was humanly possible for any man to accomplish and naturally, in the course of time he accumulated a very considerable quantity of notes and partially completed papers. A number of these uncompleted projects were very dear to his heart. Time will permit me to mention but two of them. (1) The contributions to dynamic meteorology or to climatology, submitted by eminent meteorologists for presentation at the International Meteorological Congress held in Chicago in August, 1893, which were intended to form Section IX—General and Theoretical Meteorology—and Section X—Thunderstorms—of the complete report of that Congress, failed of publication, largely because no provision had been made to defray the necessary expense. Professor Abbe, during the twenty odd years that have elapsed since the date of the Congress, has never ceased to urge the publication of those papers, and, indeed, during the last year of his active editorship of the Monthly Weather Review he began the publication of some of them in that journal.

Single-handed, Professor Abbe was unable to overcome the departmental inertia that stood in the way of the publication of these valuable contributions at the proper time. They are now of interest chiefly from a historical point of view.

The second project which he hoped to complete was a full discussion of the cloud observations made by him while a member of the U. S. Scientific Expedition to West Africa in 1889. It will be remembered that the U. S. S. Pensacola was used to transport the party to the west coast of Africa to observe the total eclipse of the sun on December 22, 1889. For this expedition, Professor Abbe devised a nephoscope to use on vessels at sea, so as to enable the navigator to observe the motions of the clouds as accurately as he observed the winds.

Professor Abbe was always cheerful, I might say, over sanguine as to the future of meteorology. Indeed, I can pay no higher tribute to his cheerfulness than to record the fact that the only note of sadness

that I ever heard him utter, in more than thirty years close association, was with reference to his inability to complete the discussion of the cloud observations before mentioned and other projects.

I first met Professor Abbe in 1884 when it was believed that he had ceased active work as a forecaster and had taken up the more congenial occupation of study and investigation. At that time he was assisted by Junior Professors Winslow Upton, H. A. Hazen and Frank Waldo, and Mr. George E. Curtis. Professor Waldo alone of this number survives.

In my first meeting with Professor Abbe I had difficulty in finding him. In those days storage facilities were inadequate and it was necessary to store in the working rooms much of the material upon which the investigative force was engaged. After dodging sundry boxes and temporary shelves I finally came to the corner in which he was located. I was instantly rewarded by the warmth of his greeting and the sympathetic response to my inquiries.

His remarkable memory, his comprehensive view, which embraced practically everything that had ever appeared on the horizon of meteorology, his powers of observation, together with his linguistic ability, made him a veritable storehouse of information. As we have before intimated, the cheerfulness with which his knowledge was imparted to others, was a striking characteristic of the man.

As the poet phrased it:

> "Of manners gentle, of affections mild:
> In wit a man, simplicity a child."

Even under the stresses that sometimes arose in the early days of the service and indeed in some of the later days, Professor Abbe never lost his poise; never "sulked in his tent." He had the ability, as one of his colleagues has expressed it, of "being able to bend without breaking and to straighten up when the blast was over." By reason of his rank as Senior Scientific Assistant he was the target for more than one ill-advised attempt to belittle scientific methods in the conduct of the work of the Weather Service. Fortunately these efforts came to naught.

It would be unfortunate to close this memoir without reference to Professor Abbe the man, as distinguished from Professor Abbe the Scientist. While his studious habits afforded little time for relaxation, yet on occasions, rare it is true, he was able to relax as completely as anyone I ever knew. Two special occurrences come to mind. At the Weather Bureau convention held in Milwaukee, Wis., in August, 1901, on which meeting Professor Abbe was in attendance, the delegates, after a rather strenuous session, were taken on a sight-seeing trip around the city, finally fetching up at the Press Club where there was the usual good cheer and general abandonment of the formality

which had characterized the official meetings. No one who attended the Press Club gathering will soon forget the brief session of social relaxation and especially the "hit" of the occasion which was staged by "Old Probs" who, mounted upon a convenient table as a vantage point, gave an ocular demonstration of the manner in which German University students consume that for which Milwaukee is famous. Needless to say, so unique an occasion formed an indelible impression upon the memories of his audience. It was characteristic of the man, even in moments of relaxation, that he was able to bring up memories of some previous event that were germane to the moment.

While at the Mount Weather Observatory it was my good fortune to have Professor Abbe and his wife as members of the official family. I shall not soon forget on occasions when extraordinary snowstorms made locomotion somewhat difficult, the picture of Professor Abbe on his way to the Mess-Hall, dressed in a great fur coat and high boots, floundering and rolling in the deep snow, with the zest of a ten-year-old boy.

Many honors came to Professor Abbe during his active career. Perhaps the two which he most prized were the Symons Memorial Gold Medal, bestowed by the Royal Meteorological Society of Great Britain in 1912, and the Marcellus Hartley Medal, awarded on April 18, 1916, by the National Academy of Sciences of the United States.

The Council of the former society, in awarding the medal, said in part:

"Professor Abbe was one of the first to realize the importance of experimental investigations of atmospheric radiation and it was largely due to his enterprise that the well-known researches of Hutchins and Pearson were undertaken. The importance of this work has been recently emphasized by its application to the explanation of the isothermal conditions of the upper atmosphere. Professor Abbe has contributed, therefore, to instrumental, statistical, dynamical and thermo-dynamical meteorology, and forecasting. He has, moreover, played throughout, the part not only of an active contributor, but also of a leader who drew others into the battle and pointed out the paths along which attacks might be most successful."

The award of the Marcellus Hartley Medal, "for eminence in the application of science to public welfare," coming from an association of which he had long been a member, was to him an honor beyond price. His death occurred just about six months after the presentation of the medal and thus passed from us a loyal son of science, an enthusiast who led the way, set a high standard of achievement, rejoiced in the good work of others and was always a friend to man.

MEMOIR OF HENRY GANNETT

N. H. DARTON

Henry Gannett was born at Bath, Maine, August 24, 1846. He attended local schools until his twentieth year, when he went to Harvard College. Here he graduated, receiving his baccalaureate in science from the Lawrence Scientific School in 1869, and the next year the degree of mining engineer at the Hooper Mining School. He continued work at the Harvard Astronomical Observatory from 1870 to 1871, and in 1871 went to Spain with Professor Pickering to observe the eclipse of the sun. In 1899 Bowdoin College gave him the degree of LL. D. He was diverted from astronomy by an invitation to join the Hayden Survey and until his death continued with this survey and its successor, the U. S. Geological Survey, except for temporary assignments to other bureaus for census work. In 1874 Henry Gannett married Mary E. Chase of Waterville, Maine, who with two daughters and a son survives him. After an illness of several months, through which his associates gathered around him in devoted comradeship, Gannett died on November 5, 1914.

Gannett was one of the founders of the Association of American Geographers and took an active part in several of the earlier meetings. He was dear to many of our members as an intimate friend, who had worked in close harmony with them through the many years of his energetic life, and he was universally known for his geographic productions. Early in 1883 he helped to found the National Geographic Society. He was chairman of the Research Committee of this society until his death, and took an active part in organizing the expeditions to Mount Pelee and La Soufriere, the Polar Seas, Alaska and Peru. He held several offices in the National Geographic Society, and was its president from 1910 until his death. In this position he won the loyal and loving esteem of his co-workers.[1]

Gannett very early in his career realized the importance of geography as a basis for many sister sciences and his most zealous efforts were directed to disseminating geographic knowledge and fostering an appreciation of it in the popular mind. In fact, the presentation of facts for popular utilization was the principal purpose of Gannett's work. In his maps, in his forestry studies, in his conservation investigations, and in his census reports, he endeavored painstakingly to present facts in such a way that the public could assimilate them to advantage.

As a map producer Gannett well deserved the title "father of

[1] See Memorial of Henry Gannett, S. D. N. North, National Geographic Society, Washington, D. C., 1915.

American map making," which was often applied to him. In 1871, at the age of twenty-one, he joined the Hayden Survey and began a career in topographic mapping which is unique in many respects. Most of the work was in the western wilderness, at that time unexplored and savage, and he rapidly produced excellent reconnaissance maps of wide areas. These were intended to serve as a basis for the geological investigations which closely followed and in some cases were contemporaneous. He had the intrepid spirit of the explorer and at the same time the genius of the map-maker. When the conditions in the field and the requirements are considered, his results were remarkable. Every trip that Gannett made in the eight years of his early exploratory work, resulted not alone in maps but in the collection of geographical data of various kinds which were useful to him in later work.

In the same way Gannett's work as chief geographer of the U. S. Geological Survey tended always to the exposition of facts that could be utilized for other scientific investigations, especially the geological reconnaissances of the early stages of the Survey. During the fifteen years of Gannett's service as chief geographer of the U. S. Geological Survey, most of its methods of map-making were developed under his direction. His energy, originality and ability to inspire intelligent work were factors that had an important bearing on the output of the topographic branch. His "Manual of Topographic Surveying" was a very useful exposition of the Survey's methods and was in such demand that it was republished as a Bulletin (No. 307).

Gannett was an indefatigable compiler of geographic materials, bringing together data for the contour and other general maps of the whole United States, and for many special maps of various kinds, such as those showing magnetic declination, and rainfall. He supervised the preparation of gazeteers of several states and of Cuba, a review of data on boundaries and areas of our states and territories (Bulls. 226, 302), an account of the origin of place names in the United States (Bull. 258), an analysis of river profiles (Water Supply Paper 44), and a discussion of the mean altitudes of the United States.

As in topography, so also in forestry, Gannett's work was largely of a pioneer character. It antedated the conservation movement by a decade, and the statistics he had gathered in that time were found immediately available for the use of the Bureau of Forestry on its organization. His special talents were appreciated when the National Conservation Commission was appointed and Gannett served as its geographer and editor from 1903 to 1909. The reports of this Commission are an example of Gannett's vast energy in the search for facts, his cleverness in correlating them and his prophetic realization of their value in the future development of our country.

In the census work which Gannet first undertook in 1880 there was

a wide and virgin field for his great ability for orderly organization. He was geographer of the Tenth, Eleventh and Twelfth censuses, and assistant director of the censuses of the Philippine Islands in 1903 and of Cuba in 1907. The results of this insular work were published in several interesting volumes, setting forth not only the purely statistical results, but giving also many valuable facts concerning the resources and possibilities for development of the islands.

Gannett's published contributions to physiography or geomorphy were not numerous, but he made many valuable suggestions to his associates. He was one of the first to recognize hanging valleys and to point out their significance. His most notable publications in this line were the two physiographic folios issued by the U. S. Geological Survey in 1898 and 1900. Each consisted of ten typical maps selected from the Survey sheets, with text prepared by Gannett.

In many of the Hayden reports and annual reports of the U. S. Geological Survey are articles by Gannett, covering a surprisingly large field of investigation. Besides these generous contributions were professional papers, principally on forest conditions, and bulletins on various subjects. In addition to articles in encyclopedias and in other works of reference, including Baedecker's Guide to the United States, Gannett wrote for outside publication his "Building of a Nation" (1895), and his "Commercial Geography" (1895), the latter in collaboration with Garrison and Houston, and a volume on the "United States" in Stanford's Compendium of Geography in 1898.

One of Gannett's most important services to geography was the organization of the Board of Geographic Names, which, beginning as an informal association with Gannett as a moving spirit, has become a permanent body in the federal service. This Board consists of representatives of several federal bureaus appointed by the President; its function is to consider geographic names used officially. Gannett was chairman of this Board from 1894 and guided its work with great success.

Gannett was secretary of the Eighth Geographical Congress, held in the United States in 1904. He was a founder of the Geological Society of America; a corresponding member of the Royal Geographical Society of London, of the Scottish Geographical Society and of the Geographical Society of Paris. He was a member of the American Geographical Society and for many years associate editor of its Bulletin. He was also a member of the American Statistical Society, the American Economic Association, the National Geographic Society, and of the Washington Academy of Sciences.

In the death of Henry Gannett American Science has lost one of the pioneers who had an important share in the development of geography in this country into an organized science.

TITLES AND ABSTRACTS OF PAPERS

New York, 1916

Presidential Address—Mark Jefferson.

Geographic Provinces of the United States. See page 3.

William Bowie.

The Gravimetric Survey of the United States.

The gravimetric survey of the United States may be considered to have been begun in 1890, when the Mendenhall one-half second invariable pendulums were first used. Previous to that date, 13 stations had been established in the United States, but the pendulums used in connection with them did not give very accurate results, as the later work showed.

With the invar pendulums the probable error of a station in the United States, referred to the Potsdam system, is, on an average, about ± 0.002 dyne. This is about one part in one-half million.

In December, 1908, there were 47 stations in the United States, established by means of the Mendenhall pendulums; while in December, 1916, there were 259 stations in this country.

The pendulum data are of value, first, in the determination of the flattening of the earth and the terms in the gravity formula. Second, they give the value of the intensity of gravity which is needed in physical and chemical laboratories. Third, they are used in researches into the subject of isostasy.

It was this latter use of gravity data which was considered at length in the paper, and the results of the most recent investigations into the subject of isostasy by the author were given.

His value for the depth of compensation as derived from gravity observations alone was 95 kilometers. The value for the depth of compensation derived by Hayford, from previous investigations, from data in mountain stations, was 97 kilometers. The author believed that the means of these two values is the best depth of compensation from all gravity data.

The flattening of the earth, derived from 358 gravity stations distributed in a number of countries, is 1/297.4. This value agrees very well with those previously determined which have been considered strong.

The author stated that a rather decided relation was found between gravity anomalies and coast topography but that there was no apparent relation between the anomalies and any other class of topography.

Some decided relations were found between the gravity anomalies

and certain geological formations, especially the Pre-Cambrian and the Cenozoic.

He stated that further work on the gravimetric survey of the United States will be done by the Coast and Geodetic Survey and he expects that it will lead to important discoveries regarding the distribution of densities in the outer portions of the earth, especially within the outer ten miles.

Charles F. Brooks (Introduced).
New England Snowfall.

New England is famous for its northeast snowstorms. These great storms, however, are not widespread, for New England, though small, has very different conditions of exposure to the snow-bearing winds. The highlands are the snowiest because they are cold, moist and windy. Particularly snowy are those slopes which are openly exposed to easterly or northeasterly winds, or in the north, to the westerly winds from the Great Lakes. The intermontane valleys have less snowfall because of the higher temperature, smaller precipitation and less exposure. In the coastal region, since the other conditions are favorable, the snowfall depends on the temperatures. As a result, the snowfall of the second half of the winter is the greater; and also the coast may be said to exceed the inland snowfall then, if due allowances are made for topography. New England, as the focus of most of the cyclones which cross the United States or come up the east coast, has all parts traversed by numerous centers. The strongest cyclones pass New England on the south or cross through the southeast; so this section from time to time has a characteristic "old-fashioned snowstorm."

Godfrey L. Cabot (Introduced).
Maps for Use by Aviators.

Collier Cobb.
Colonial Transportation in North Carolina.

W. S. Cooper (Introduced).

Plant Succession after Glacial Recession in Alaska.

Studies were made during August and September, 1916, of the establishment of vegetation after glacial recession in several localities in southeastern Alaska. Glacier Bay was found to be especially favorable for such study, because of the extremely rapid recession which has taken place during the last century and a quarter, and because the positions of several of the ice fronts have been accurately located several times during recent years. The stages in the vegeta-

tional succession were worked out in detail, and the time factor was studied by age counts of woody plants. Permanent quadrats were located at the ice limits of known date, for the determination of successional progress in a known period of years, and for future study. The present paper is not a record of finished research, but an announcement of work in progress, given with the hope of co-operation from any one who may visit the region in future years. The quadrats are so located that they may easily be found, and charts or at least photographs of them made at future times will be of great value.

Sumner W. Cushing.

Shīharikota and the Yānādis. See page 17.

W. M. Davis.

The Sea Cliffs and Coral Reefs of Tahiti.

Tahiti, the largest of the Society Islands, is a volcanic doublet, submaturely dissected by radial consequent valleys, the larger cone being 17 nautical miles in diameter, and 7,381 feet in height; the smaller one, southeast of the other, 8 miles, and 4,341 feet; a low isthmus, but little more than a mile across, connects the two. As Dana long ago noted, the central parts of the cones are destroyed, and there the narrow inter-valley ridges are sharply serrate; but in the peripheral slopes, where the radial consequent valleys are farther apart and less deep, the ridges descend in slanting spurs, topped by sloping triangular sectors which represent the initial slope of the cone, little worn. Dana and nearly all later observers failed to mention the mature sea cliffs in which the radial spurs terminate; but they are well described by Agassiz (1903) as rising in some instances more than 1,000 feet above sea level along the windward eastern coast, and as sometimes undercutting small valleys from which the streams fall in cascades. The cliffs are not vertical, but dip at angles of 40°, 50° or 60°.

The larger valleys descend below present sea level, for some of them are entered by arms of the sea, and all the others are occupied near their mouths by triangular delta plains, which commonly extend beyond the line of sea cliffs and unite in a confluent alluvial strand plain, on which almost the entire population live. The valley ends being submerged, the cliff base line and the abraded platform that must extend in front of the cliffs must also be submerged. That such is the case is indicated by depths of over 20 fathoms close along shore, while off the cliff coast of Normandy, where the sea is still cutting at the cliff base, a depth of only 10 fathoms is not found for one or two miles off shore.

The discontinuous barrier reef by which both cones are surrounded

encloses a lagoon from half a mile to a mile or more in breadth, and from 15 to 30 fathoms in depth. Contrary to the belief of Murray and of Agassiz, the better enclosed parts of the lagoon appear to be filling up by inwash of calcareous detritus from the reef and by outwash of volcanic detritus from the island. The reefs could not have been present while the cliffs were cut back; and some change must have occurred to alter the reef-free, cliff-cutting conditions then obtaining into the reef-building conditions now obtaining. This change appears to have been the submergence by which the abraded platform and the valley mouths were drowned. Previous to the submergence Tahiti must have resembled the volcanic island of Reunion in the western Indian Ocean, where cliffs now rise from a wave-swept beach of volcanic detritus, which presumably lies on an abraded platform and which inhibits reef growth because its cobbles and gravels are frequently shifted by the waves. If submergence should occur there, the detritus from the valleys would be pocketed in the valley embayments, the abraded platform would be swept comparatively clean, and reefs might then grow up from the platform, as they are now growing up from the submerged platform around Tahiti.

The bearing of these facts and inferences on several theories of coral reefs was discussed. All the theories which postulate a fixed relation between the reef foundations and the surface of the ocean are excluded by the evidence of submergence, given above. As the depth of submergence, determined by prolonging downward with decreasing declivity the side slopes of some of the delta-filled valleys, is 500 or 600 feet, neither a rise of the ocean due to an uplift of its bottom elsewhere, nor the rise of the ocean at the close of the Glacial Period can be accepted as the whole cause of submergence; the remaining cause must be sought in the subsidence of Tahiti itself, and thus Darwin's theory of intermittent subsidence is supported.

The relation between the narrow, steep-sided valleys of Tahiti and its high, mature sea cliffs has an additional and important bearing on the Glacial-control theory, as follows: This theory assumes that, when the ocean was chilled and lowered (33 to 38 fathoms) during the Glacial period, the corals of most reefs were killed, and the dead reefs were then abraded by the waves; it also assumes that the embayed valleys, by which the central islands of barrier reefs are characterized, were eroded while the Glacial ocean was lowered and were drowned when the Postglacial ocean rose to its present level; and it explains the absence of cliffs on the spur ends between the embayed valleys of such islands by the resistance of the lavas of which the spurs are composed. Tahiti shows that this explanation is not correct; for the same period which sufficed for the immature erosion of the narrow Tahitian valleys sufficed also for the mature erosion of the Great Tahitian cliffs; hence in other islands, where the embayed valleys

are as a rule more mature than those of Tahiti, the spur ends should now be more strongly cliffed, if the encircling reef had been killed and abraded during the Glacial period. But except for little bluffs, 10 to 50 feet in height, fronted by shallow rock platforms and therefore the work of the lagoon waves at present sea level, the spur ends of other islands are not cliffed, and therefore their reefs were not killed and abraded; and thus certain essential elements of the Glacial-control theory are discredited. Appeal should not be made to a supposed superior resistance of the rocks in the non-cliffed islands, for which there is no warrant; for if their rocks are more resistant than those of Tahiti, then the erosion of their mature valleys must have been very slowly accomplished; and if the erosion period of only narrow valleys in the supposedly weaker rocks of Tahiti was sufficient for the abrasion of great sea cliffs, then the erosion period of wider valleys in the supposedly harder rocks of the other islands should have been sufficient for the abrasion of still greater cliffs, provided the encircling reefs were at that time dead. But as these greater cliffs are not found, the reefs cannot have been killed; hence the supposition of superior resistance in the rocks of the non-cliffed islands is not only unwarranted, but unavailing. Tahiti thus indirectly gives strong support to Darwin's theory of upgrowing reefs during intermittent subsidence.

J. W. Goldthwait.

A New Model of the Mt. Washington Range in New Hampshire. —Read by Title.

The model, which is here exhibited for the first time, is based on "A map of the Mt. Washington Range," published by the Appalachian Mountain Club in 1914. It is about six feet by four, and includes not only this central range of the White Mountains, but the adjoining valley of the Saco at Crawford Notch, Bartlett and Jackson, the Ammonoosuc valley at Bretton Woods and Fabyans, the Androscoggin valley at Gorham, and "the Glen." The scale, both vertical and horizontal, is three inches to the mile. The absence of vertical distortion affords a realistic view of the mountain slopes, in which attention is particularly called to the somewhat peaked, though glaciated summits, the extensive graded "lawns" or "alpine pastures" and the cirques carved in the flanks of the range by mountain glaciers.

J. Paul Goode.

A New Idea for a World Map: A Substitute for Mercator's Projection.

There is a growing protest among teachers and students against the use of Mercator's or other cylindrical projection, showing the earth's surface as a unit, because of the progressive distortions of area with

increase of latitude. It is realized that the continual use of Mercator's projection fixes in the mind of the observer very erroneous impressions of the relative sizes of areas, and that these bad impressions persist, in spite of every caution and every effort to fix true relations by study of other projections.

The contribution here presented is a method of interruption of Mollweide's homalographic projection, such that each continent in turn is given the great advantage of a place in the middle of the grill, where the maximum truth of form is guaranteed. The homalographic projection is an equal area projection, thus continents and other unit areas may be compared with each other in their true size. Also this projection, in common with Mercator's projection, offers the very great advantage of having latitudes represented by right lines, trending with the equator, facilitating the study of comparative latitudes. The homalographic projection also shows the earth's surface *entire,* a thing the Mercator's projection can not do. For all these reasons the interrupted homalographic projection as here presented, offers the maximum of teaching advantages for all study of world distributions.

Roland M. Harper.

The Forests of the Eastern United States: Their Past, Present, and Future.

About seven-eighths of the territory of the United States east of the Great Plains was originally covered with forests, of great diversity, including such types as the spruce forests of the extreme north, the hardwoods of the Ohio valley, the long-leaf pine of the southeastern coastal plain, and the tropical hammocks of southern Florida.

In the last 200 years or so, the forest area has been reduced about 40% and the total stand of lumber about 60%. The early exhaustion of the forests has often been predicted, but such predictions have nearly always turned out to be exaggerated. The influences tending to preserve the trees seem at present to be nearly equal to the destructive influences, and our forests promise to be an important source of wealth for many years to come.

Alfred J. Henry.

Flood Producing Rains in the United States, 1916.

The rainfall of 1916 in the United States was characterized to a considerable extent by the occurrence of heavy rains in pairs, the first storm being almost immediately followed by a second equally severe storm that swept over a nearly identical path and thus there was naturally an extraordinary concentration of rainfall over restricted

areas. Such concentration was especially noted in southern California and Arizona and again in eastern Oklahoma, Arkansas, Missouri, southeastern Kansas, Illinois and Indiana, in the latter part of January.

In July two tropical cyclones passed inland, over the East Gulf and South Atlantic States, the first in the vicinity of Mobile, Ala., and the second near Charleston, S. C. The intensity of the rainfall attending these storms was in many cases extraordinary and the concentration of rainfall over rather wide areas resulted in severe general floods which in some localities were unpredecented.

The loss of life in the January and July floods was about 130 and the property loss for the entire year about 36 millions.

R. S. Holway.

The Marine Terraces of California and Related Problems.

George D. Hubbard.

Possible Local Glaciation in Southern Vermont.

The communication was a preliminary report only and contained a brief description of the moraines, eskers and kames found during the summer of 1916 in the vicinity of Wilmington, Vermont. These features are very abundant and have not been disturbed by ice since they were made. They seem to indicate a large development of valley dependencies on the margin of the waning Wisconsin ice sheet, or local valley glaciers after the withdrawal of the continental glacier. The latter explanation is believed to be supported by the following evidence: 1. The valleys in which these features lie are closed in on the west by the Haystack-Pisgah range and on the north by another high range, cols of which show no signs of having been spillways for glaciers. 2. The moraines, looped across the valleys, are arranged with reference to the heads of the local mountain valleys, heads pushed against the peaks instead of the cols. 3. One valley head has a well formed cirque occupied by a lake in a rock basin. Fresh moraines loop across this valley at many points entirely up to the lake. A detailed field map was shown.

Ellsworth Huntington.

Fluctuations of Our Southwestern Lakes.

A study of a series of basins at the eastern base of the Sierra Nevada in 1914 confirms the conclusion that there have been marked variations of climate during the past few thousand years. In some cases old strands have been covered by alluvial fans during a dry period when the lakes fell to a low level. Upon these four other abandoned strands are now visible, showing that the water rose once more almost

to the previous level. This indicates not only a general fall in the level of the lakes, but a series of oscillations first one way and then the other, with a general tendency toward aridity. At Owen Lake Gale's study of the salts dissolved in the lake and in the river which feeds it, indicate that the period since the last overflow can scarcely be more than 2,500 years. This makes it possible to correlate the strands with the fluctuations in the growth of the big trees on the opposite flank of the Sierras. The harmony between the cycles indicated by the strands and by the trees is close. Other lakes such as Mono and Pyramid show similar indications of fluctuating climate.

In studying the cause of such fluctuations the first step seems to be to ascertain exactly what sort of changes are in operation at the present time. At Lake Mono, for example, there has been a recent rise of level. In 1914 the water stood higher than at any other time for at least 130 years. This is indicated by the rings of certain trees which have recently been killed by the rising of the salt water. It is interesting to note that within a comparatively few years many old trees have been killed by an opposite cause in India and South Africa. In both of these cases extreme drought occurred upon the equatorial side of the subtropical belt, whereas the California lakes lie upon the polar side of that belt. This seems to indicate a cyclical shifting of zones which is even now in progress. It produces marked effects in certain border regions, but is comparatively unimportant in the central portions of the zones. The shifting seems to take place in harmony with variations in solar activity and in the consequent paths of storms.

W. L. G. Joerg.

Relief Models as a Source of Information for the Geography of the United States.

The paper dealt chiefly with the utilization of existing relief models of states and other portions of the United States for the representation of generalized relief on maps. The contour method, although admirably suited to detailed maps such as to the topographic sheets of the U. S. Geological Survey, does not lend itself well to general maps. On these relief is best represented in a plastic manner, as by shading or hachuring. As this method is not as highly developed with us as it is abroad, we have resorted to modeling. The paper suggested using photographs of the numerous existing models of scientific worth either directly as relief bases for maps of their respective areas, to be reproduced, for example, in half-tone, or indirectly, as a guide for a shaded drawing. A survey of these models, which cover, as far as it had been possible to ascertain, 22 states or about one-third of the total area of the country, was given, illustrated by lantern slides of the majority of them. An additional value which attaches to these models is due

to the fact that many of them cover regions for which no topographic sheets exist or the topography of which is otherwise not readily available.

Lawrence Martin.

Gravel Terraces of the Mississippi River in Wisconsin—Read by Title.

The terraces of the Upper Mississippi in Wisconsin and across the river in Minnesota and Iowa are distributed through a distance of 213 miles directly, or 260 miles as the stream flows. The river has a terrace on one side or the other for 126 miles of this distance—the length of all terraces, including those that overlap and also parallel terraces in steps being 200 miles. The largest terrace is 15 miles long, 3 miles wide, with an 80-foot scarp facing the river. One terrace in the middle of the valley is 9 1/3 miles long, 3/4 of a mile wide, and stands 30 feet above encircling floodplain deposits. The terraces are made up of outwash sand and gravel of Wisconsin age. They lie in the bottom of a preglacial gorge or trench, bordered by precipitous bluffs 230 to 650 feet high. The rock floor of the gorge lies 150 to 210 feet below the present river level; the higher terraces rise more than 100 feet above the river; hence the gorge is really 750 to 800 feet deep in places and the terrace gravel is 200 or 300 feet thick. The Mississippi floodplain in Wisconsin is nearly everywhere swampy; accordingly the terraces supply practically all the improved farm land and the sites of all the river cities and villages, including La Crosse and Prairie du Chien, Wis., Winona and Red Wing, Minn., Dubuque, Iowa, and many others.

The terraces fall in two groups: (a) few small and low terraces south of La Crosse; (b) numerous, large and high as well as low terraces to the north. There are usually two low terraces—20 feet and 40 feet above the river. North of La Crosse, where there are terraces for 87% of the distance, the low terraces are usually present and there are higher terraces, entirely absent to the south, four or more in places stepping up the 105 feet or higher above present river level.

The explanation of this increase in number and height of terraces seems to be that, as in the case of beaches of the Glacial Great Lakes, (a) the terraces remain parallel downstream from the southernmost of the hinge lines, (b) they increase in number and in altitude to the north of this line, which appears to cross the Mississippi in the neighborhood of La Crosse close to or a trifle farther south than where Taylor (conjecturally) places the Whittlesey hinge line. The uplift of the land toward the end of the Glacial Period is thus seen to have had the normal effect on rivers, the terraces in the tributaries of the Upper Mississippi appearing to respond to the same control.

Emmanuel De Martonne (Introduced).
The Physiography of the Carpathian Mountains.

A. E. Parkins (Introduced).
The Development of Manufactures at Detroit.

Although Detroit was founded in 1701, it was not until the early part of the nineteenth century that the real development of manufacturing began. For nearly 150 years commerce was the dominant interest of the settlement.

In 1810 the total value of manufactures was $24,742, in 1909 the value was $223,000,000. This wonderful growth is for the most part only a normal growth, characteristic of several cities of the Interior, and is chiefly the result of the westward migration of people, resulting in an increasing density of population, and a westward migration of manufactures. Fundamental to the normal growth lie the wonderful improvements in transportation that characterize the last century.

Among the broader geographic factors operative at Detroit are those associated with its position. It is situated on the largest and most important series of waterways in the world and near the entrances to the "Gateways" through the Appalachian Barrier. Since the beginning of the railroad era its position on one of the great trunk lines of the country is of vital importance, particularly since the Detroit River here occasions a break in land transportation only partially overcome by car, ferry and tunnel (the latter since 1910). The city is within easy reach of the copper and iron ore deposits of the Lake Superior Region and the coal of the Appalachian fields. It is on the border of the most productive agricultural region of the United States, and for many decades had access to large forests of commercial timber. Being the oldest settlement on the lakes, for a long time it enjoyed almost a monopoly of the benefits arising from these important factors.

Roderick Peattie (Introduced).
The Geography of the Lower St. Lawrence Valley.

The Lower St. Lawrence Valley includes the valley slopes from Quebec to the Gulf. The north shore, except for a few fertile wedges, has a broken settlement with a meager economy. The south is densely populated, excellent farms running ten to twenty miles back over the gentle uplands. On both shores the commerce is chiefly in wood products, cheese, butter and live stock. For the most part the settlements, especially to the north, are economically independent. In this well-defined, isolated unit-area still prevails an ancient economy, language, philosophy, folk-lore and architecture, crystallized to an extraor-

dinary degree and creating a significant provincialism. This study is the result of a library investigation followed by field work in the last season.

William Gardener Reed.
Plimsoll's Mark.

The classing of vessels according to seaworthiness has been practiced in England for nearly 200 years. It has been recognized that the conditions on different oceans and at different seasons are not the same. Insurance by distributing the risk also made it more possible to send vessels to sea in bad weather. In the sixties overloading appears to have been common, and Samuel Plimsoll began his efforts which resulted in the adoption of a load-line mark by 1876. It was not until 1894, however, that the position of the mark was fixed by government authorities. In 1899 the Board of Trade determined different load-lines for fresh water, for "Indian Summer," for summer, for winter and for "North Atlantic Winter." Since then Germany and Denmark have adopted "Plimsoll's Mark." The adoption and use of this mark emphasizes the influence of geographic conditions on commerce.

Lawrence V. Roth (Introduced).
Geographic and Historic Factors in the Growth of Certain American Cities.

The movement of population towards the larger cities in the United States falls into four periods, each introducing a new geographic area. The first period begins with our Colonial history and the development of cities takes place along the Atlantic Coastal Plain; during the second era, beginning about 1810, city growth is most notable in the Mississippi valley along the river fronts; beginning about 1850, a third era opens and the cities of the Great Lakes district have a notable growth; during the fourth period, opening about 1900, a relatively sudden movement of population is found on the Pacific coast. Significant geographic and historic factors were read into this movement of population as shown graphically on a large chart.

H. L. Shantz and Raphael Zon.
A New Classification of the Native Vegetation of the United States into Natural Groups.

The vegetation of the United States was divided into plant formations defined as the largest vegetation units which could be distinguished by comparative uniformity of physiognomy, of botanical composition, of climatic and environmental conditions, and by con-

vergent development. On this basis the distribution of two grass formations, three desert shrub formations, nine forest formations, and five minor communities was mapped.

Eugene Wesley Shaw.

Notes on Man and Nature in Tamaulipas and Vera Cruz, Mexico. —Read by Title.

1. *Relations of pre-Columbian aborigines to environment.*

Indians.—Various bloods and natures but generally religious, superstitious and social. Surface.—Plains with irregularly scattered commonly conical mountain peaks and occasional ranges up to 4,000 or 5,000 ft. in height, some of which are not shown on current maps. Temperature.—Average probably low for tropics, cold often penetrating; blanket needed nightly, hence part of costume. Soil.—Calcareous and fertile. Precipitation.—Rather low, increasing southward. Vegetation.—Forest a thorny thicket rather than tropical jungle, almost uninterrupted. Wild animals.—Natural supplies of wild meat fairly good,—deer, large and small birds, sea and river fish, shrimp, etc. Snakes and mosquitoes much less troublesome than wood ticks and other insects.

2. *Changes in customs and relationships due to 16-19th century events.*

Perhaps because of oppression of large part of population, many aboriginal customs have been retailed with slight modification. Mingling of bloods general, but apparently one-fourth of the population are pure Indian. Most of them have been more or less enslaved, some driven into the mountains. Diet.—Corn, as before, the main article, ground by hand just before being made into tortillas (unleavened cakes); black beans, meat, peppers, tomatoes (type locality—Aztec tomatl), sugar, coffee, bananas, etc.; chile and tamales not omnipresent. Dwellings.—"Bamboo cages" thatched with palm leaves or straw and often chinked with mud; adobe rare. Doors and windows scarce. Religion.—Mostly Roman Catholic, some pagan; curious mixtures common. Transportation.—Some by railways and wagons, but mostly on backs of burros or men. Surprising lack of wagon roads, even where surface is smoothest. Amusements.—Drinking, dancing and gambling, including lottery on enormous scale. Bull and cock fights rare. Village life popular. Morals.—Comparatively low, but ideals not altogether wanting, and faithfulness of servants often surprising. Cleanliness.—Rivers and water holes frequented resorts for laundering and bathing. Education.—Most of population seem able to read and write Spanish but display little desire to learn English, which is surprising in cab drivers and porters.

3. *20th century changes in relationships and customs.*—due largely to discovery of petroleum and to revolutions. Wealth.—Increased for small

part of population,—oil field land owners and laborers. Psychologic equilibrium, law, deportment, industries and currency demoralized by revolutions. Differentiation increased between more bellicose and rapacious elements and more peace loving and timid. Failure of Madero's plan to redistribute land has led warlike Indians to kill or drive off many landowners. Outrages common and of many sorts, but usually with considerable show of politeness, and apparently like battle casualties, more likely to end in death than crippling. Cultivated area greatly reduced and grown up in thickets. Comparisons with ranch and mining camp wild west of United States interesting. Armed marauders are soldiers, a tattered and very poorly equipped lot, whose principal motive seems to be gain. Other men do not carry weapons openly, but often concealed knives. The almost unpenetrable thicket and the mountain fastnesses are the retreats of the timid and persecuted folk rather than the home of the robbers, for most if not all bandits seem to have joined one or another of the national factions. Natural barriers of comparatively slight importance in revolutions.

O. D. von Engeln.

Glacial Erosion of Rock Basins—With Especial Reference to the Conditions Applying in the Finger Lake Region of Central New York.—Read by Title.

The finger lakes of Central New York, of the Lake District of England and of the Italian-Swiss Lakes on the south slope of the Alp; and the fiords of Alaska, Patagonia, Norway, New Zealand and some of the Scottish lochs are all similar in outline and form of hollow. If carved by ice the basin feature of all of them is the result of concentration of the ice erosion action at particular parts of linear valleys earlier developed by streams. With the single notable exception, however, of the Central New York Finger Lakes the other basins of this nature occur where the ice movement was down valley. In consequence of this, conspicuous morainic barriers are usually present at the lower ends of these "down-valley-movement" basins, and such moraines are an expectable feature there, because the situation would normally mark the end of a pronounced ice tongue. The high wall-moraines of the Italian Lakes are especially typical examples. Such barriers no doubt account for a considerable part of the depth of the "down-valley-movement" basins.

In the case of the New York Finger Lakes, on the other hand, the ice movement was upstream—unless the preglacial drainage is interpreted to have been southward and eastward from points considerably to the north of the present divide. Even in this case the mass of the continental ice front must, in this region, have impinged on a rock escarpment of considerable height, extending east and west at right

angles to its movement. On the north front of this escarpment, in line with the direction of ice movement and apparently widening normally as they extended toward the ice front, were a number of parallel, preglacial valleys. Some of these may have had a south slope, others almost certainly sloped to the north. These valleys obviously afforded the readiest paths for the further progress southward of the oncoming ice masses and into them were thrust advanced lobes, while the main body of the ice was dammed back for the time being by the escarpment front. This dam may be reckoned of about 1,000 feet altitude. It created a "head" of ice, a reservoir from which ice poured into the north-south valleys. If the valleys sloped to the north, they must have narrowed toward their heads in the south, and this constriction offered a progressively increased resistance to the further advance of the ice. But once the ice was trapped, so to speak, in the V opening of the north end of the valleys, it could not escape these guiding lines, and crowded by the head of ice behind, its erosive effects were concentrated on the more constricted parts, as is indicated by the fact that the basins are deepest where the valley is narrowest. Later when the ice grew in thickness sufficiently to overtop the divide region completely, these valleys continued to be the channels through which the deepest and presumably the most rapidly flowing ice moved. As a result the divides were notched along these lines and through valleys were created.

If this proposal, that the Central New York Finger Lake basins are of unique development in that they are the result of ice thrust into valleys sloping against the direction of ice advance, is unacceptable, then the only alternative is to correlate them with the other finger lake and fiord occurrences,—in other words, ascribe them to the result of ice erosion as a concomitant of "down-valley-movement" and concentration.

In this case also the flow would originate in an "ice-head" back of the escarpment slope. The scour would further tend to be concentrated where the source volume and downslope acceleration conjointly made themselves most effective. In the wider parts of the valleys beyond the divide ridge there would occur broader distribution of uniform rate of flow, decreased velocity because of decreased slope; and, during the waning, lobate phases, pronounced accentuation in thickness of deposit, as valley-fill terminal to the lobes.

This valley-fill would then constitute a main part of the barrier creating a lake basin. If a rock basin constituted part of the depression its development would be on a much smaller scale than in the other case. The fact that near surface rock barriers cut off at least part of the width of the valleys to the north, while borings up to 1,000 and more feet in depth fail to disclose rock in the drift filling of the valleys to the south lends support to the south slope interpretation.

In this may be found a suggestion also for a partial reconstruction of the preglacial drainage of New York State.

Robert DeC. Ward.

Rainfall Types of the United States.

A revision of the rainfall types of the United States. Fourteen types were distinguished and each one was illustrated by a composite curve of the monthly rainfall amounts. A map was exhibited showing the geographical distribution of these types.

R. H. Whitbeck.

Some Influences of Geographic Environment upon Primitive Regions.

The religious beliefs of primitive peoples are necessarily influenced by the character of their environment. The early Norseman's heaven was a place of warmth and his hell a place of cold and darkness. Mohammed taught his desert followers that heaven is a garden with running water, trees and fruit. The American Indian believed heaven to be a happy hunting ground to which his dog, as well as himself, might go. To the Egyptian the Nile, overflowing and fertilizing his land, was a deity,—as rivers frequently are to agricultural peoples. The monsoon climate of India—differing radically from the arid climate of Bactria—gradually made over the mythology of the early Aryan invaders of India.

Geographic influence upon religious ideas is most marked among primitive peoples and declines in importance as their understanding of nature increases. The influence of geographical environment shows more in the writings of the Old Testament than in those of the New. Greek and Roman mythology reflect no dominant geographical influence partly because there was none so dominant as the Nile in Egypt, the desert in Arabia, or the monsoon in India—and partly because the Greeks and Romans had passed beyond the primitive stage of culture.

Explanation of Plate III

a Yānādi Family and Typical Home. The man holds a cleaver introduced by government for preparing firewood to send to Madras.

b A Village Group of the Yānādis. The earthen pots for cooking are brought to the island from Madras. The Yānādis have no potters.

Annals of the Association of American Geographers, Volume VII

a

b

Explanation of Plate IV

A Yānādi wife getting a meal of boiled roots. On Srīharikota broken pots hold in place the boiling pot instead of stones as on the main land, and wood serves as fuel instead of dried cow dung.

PLATE IV

Annals of the Association of American Geographers, Volume VII

Explanation of Plate V

a A Yānādi making fire by friction. Although matches are now brought from Madras, this primitive method of kindling fire is commonly used, especially when the people are away from the village.

b A group of Yānādis beside their religious house with its sun shield. One is searching for parasites in the hair of another—a favorite pre-occupation of this simple folk.

PLATE V

a

b

EXPLANATION OF PLATE VI

a Looking across the Buckingham Canal to the most important village on Srīharikota. The well-made houses have been put up for the Forest Range Offices and for a school. The rock, laterite from the mainland, is being brought here for government purposes.

b A Typical Well. The slight depth is of course due to the low altitude of the island. Such wells are the source of some of the diseases that spread among the people. See Plate VIIa.

a

b

Explanation of Plate VII

a The man with the enlarged leg is afflicted with elephantiasis arabum. The shallow open wells, Plate VIb, probably breed the mosquitoes that spread this disease. The boy in coat and turban at the left is the writer's interpreter.

b Gathering major forest products, mainly firewood, for the Madras market. A few Hindus are brought from the mainland to do the heaviest of this work. Yānādi women do the lightest work, Yānādi men do the rest.

a

b

Explanation of Plate VIII.

a A train of cars loaded with firewood ready to start.

b Yānādis engaged in pushing wood cars from the jungle to the Buckingham Canal. The level surface of the island and their habit of running down game have well adapted them to this sort of work.

PLATE VIII

a

b

Explanation of Plate IX

a A group of Yānādis who constitute the power of the government railroad on the island. They have succeeded where bullock teams failed.

b Going into the jungle of Srīharikota with the forest ranger and an interpreter on a man propelled car.

PLATE IX

a

b

Explanation of Plate X

The bi-weekly arrival of the Yānādis who are employed by the government to collect minor forest products. The bags and baskets are supplied by the government. They contain soap nuts, nux vomica, rattans, honey, plate leaves, etc. The huge scales beyond tell what the products are worth. An average day's pay is four cents.

PLATE X

Annals of the Association of American Geographers, Volume VII

Explanation of Plate XI

a Canal boats under sail going south in the Buckingham Canal driven by the northeast trade winds. They are carrying jungle products to Madras from Srīharikota. Three pullers are shown drawing the writer's house boat against the wind.

b Bundles of plates of woven leaves from the Srīharikota jungle waiting shipment at a railway station on the east coast railroad. These plates are used as dinner plates.

a

b

Explanation of Plate XII

Yānādis on the mainland employed as " jutka " pullers and pushers. Here the railroad is ballasted with laterite and runs across the young coastal plain.

PLATE XII

Explanation of Plate XIII

a Yānādis from Srīharikota living on the mainland. Their village is on the outskirts of a large town in which they work as night-watchmen. Here on the laterite soil which does not preserve the imprints of their feet they have a bad reputation.

b The mainland hut of the Yānādis is better made than his former one on the island since here he has laterite blocks and mud for building walls. Contrast with Plate III. Here, too, as shown in the foreground, laterite blocks make his fireplace instead of broken pots.

PLATE XIII

a

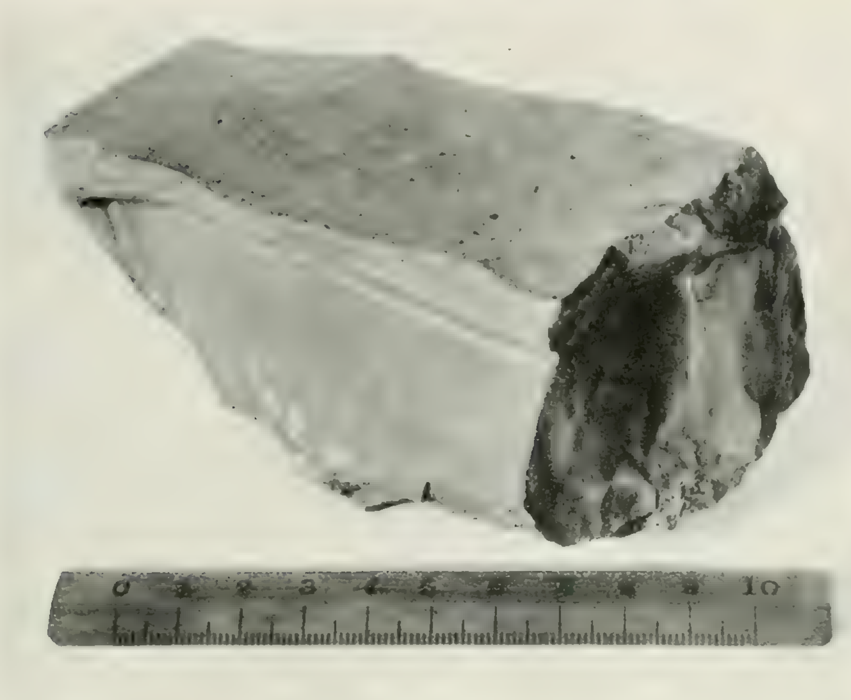
b

Explanation of Plate XIV

a Fragment of dolomitic limestone with desert rinds of calcite, which projects like a cornice through undercutting by driven sand. Libyan Desert.

b Limestone with brown color rind, but little hardened. Libyan Desert.

PLATE XIV



a

b

Explanation of Plate XV

a Desert stone with protective rind, burnished by the sand blast. To the right a later cup-like depression where fragment has snapped off and new rind has since formed. Libyan Desert.

b Color rind (ferrite) but little protective in character. Libyan Desert.

PLATE XV

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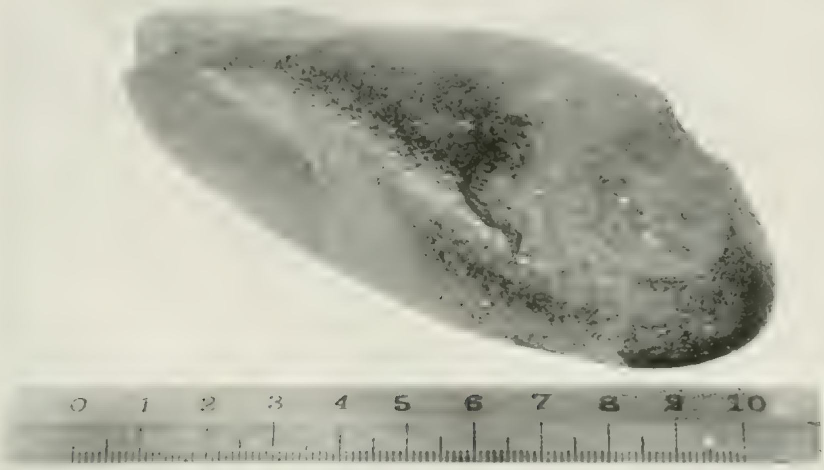

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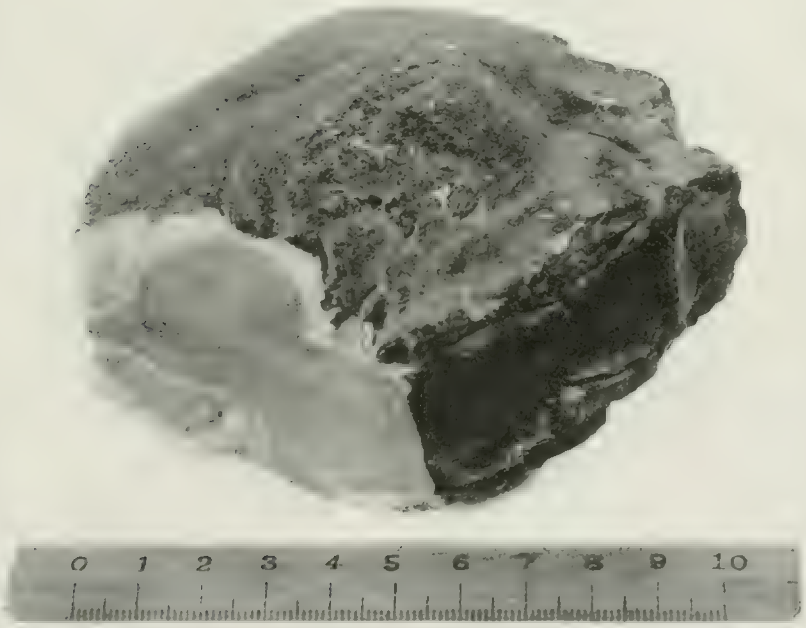


b

Explanation of Plate XVI

Undercutting of thick adobe wall of the Roman fort El Der, showing the limited vertical range of effective sand erosion to be about one meter. Kharga Oasis.

PLATE XVI

Annals of the Association of American Geographers, Volume VII

Explanation of Plate XVII

Armored surface of the desert, due to the process of deflation. Dj. Umm el Ghenneiem, Kharga Oasis.

PLATE XVII

Explanation of Plate XVIII

a Adobe corner post to cemetery at Markaz el Sherikah Kharga Oasis. The post is composed of adobe blocks covered with adobe veneer, and shows the effect of less than a year's work by the cutting sand. The southern (lee) sides are not affected.

b *Island hill* of granite in advanced stage of spheroidal disintegration. Lower zone polished by sand blast, and upper zones exfoliated. Near Jebel Gerri station, Khartum district.

PLATE XVIII

a

b

Explanation of Plate XIX

Groups of ridges remaining as residuals of lake deposits carved by sand driven from the north (left) on floor of Kharga Oasis near Markaz el Sherikah.

PLATE XIX

Annals of the Association of American Geographers, Volume VII

Explanation of Plate XX

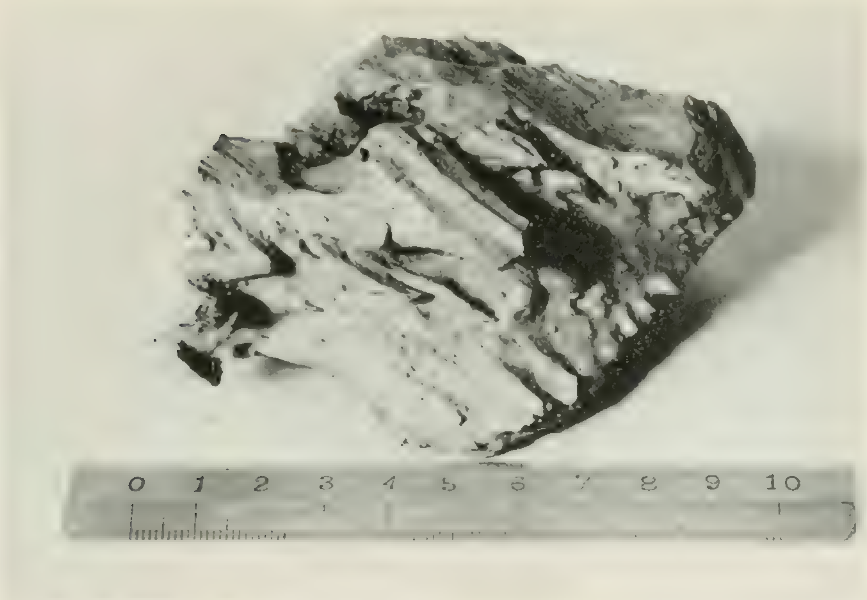
Individual asymmetrical ridge of lake deposits showing the steep undercut north or windward side and the joint planes.

PLATE XX

Explanation of Plate XXI

a Eocene limestone containing small silicious infusoria (*Operculina Libyca*) which turn the grains of driven sand and yield hoodoo like projections. J. Umm el Ghenneiem. Kharga Oasis.

b A similar specimen showing the shells capping the spines.



a

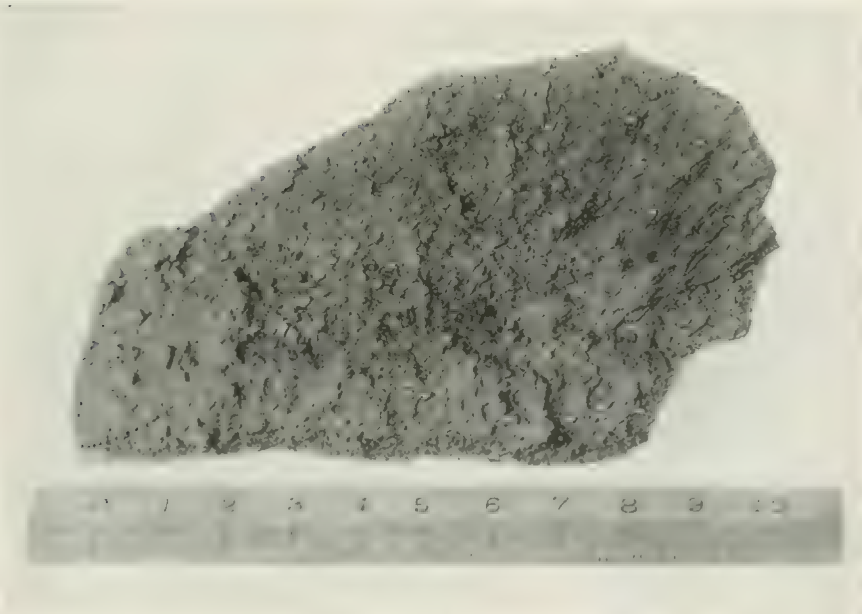
b

Explanation of Plate XXII

a Sand and dust storm of June 6, 1906 (Huboub), sweeping over Khartum north, as seen from across the Blue Nile in Khartum (after G. N. Mohrig).

b Rhyolite with phenocrysts of feldspar left in relief through drilling away of groundmass by driven sand. Shabluka Hills, Khartum district.

a



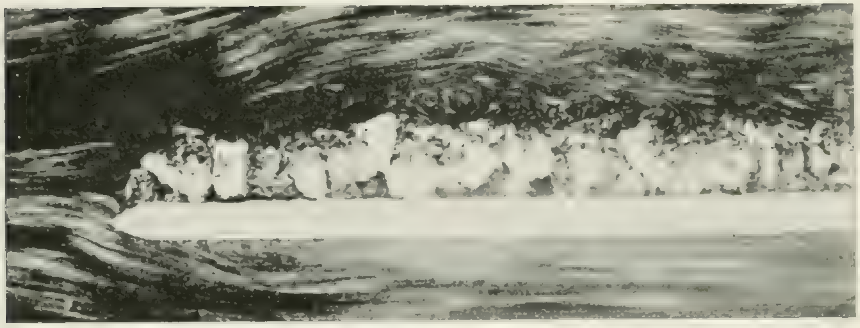
b

Explanation of Plate XXIII

a Eddies produced over a rough surface when drawn through water (after Ahlborn).

b Ruffled surface of limestone from action of driven sand. Libyan Desert west of Giza.

PLATE XXIII



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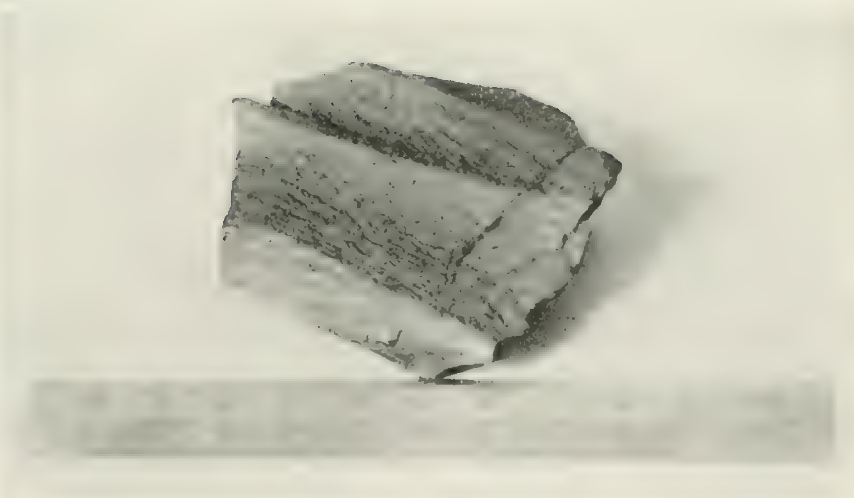

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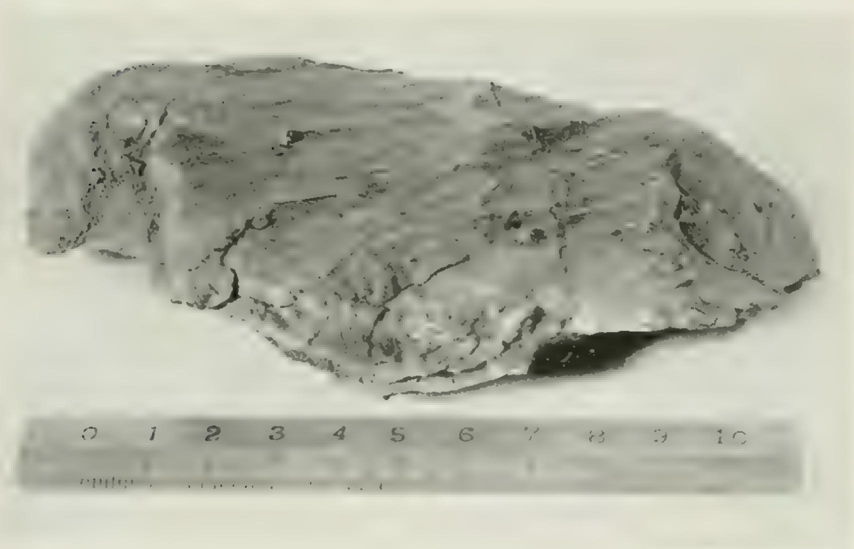
Explanation of Plate XXIV

Ruffled surface of limestone carved by driven sand. Libyan Desert west of Great Pyramids of Giza.

PLATE XXIV

Annals of the Association of American Geographers, Volume VII

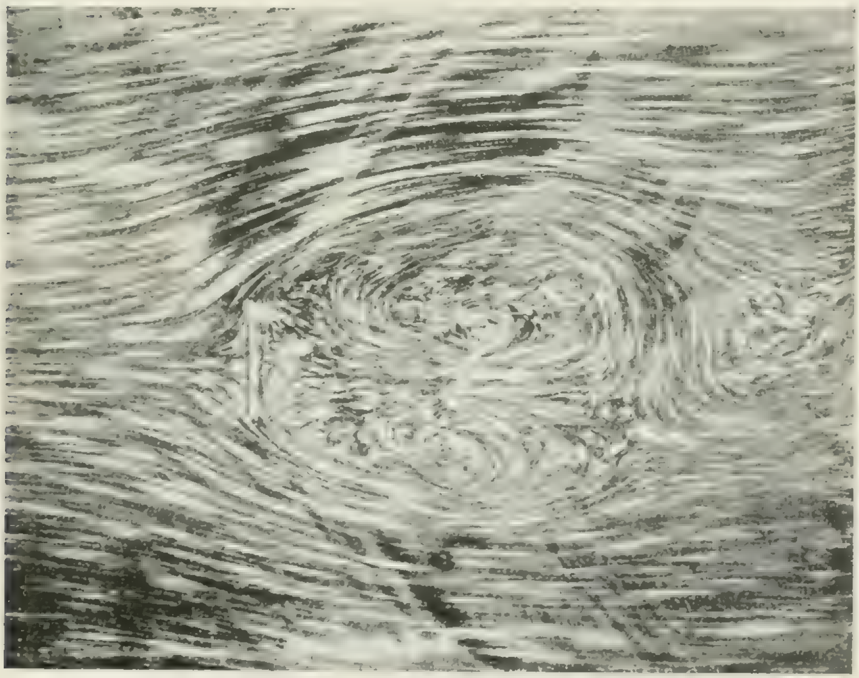


Explanation of Plate XXV

a Ruffled surface of sea simulated by the sand-cut surfaces of the limestone capping to the Libyan Hamada.

b Flow lines produced about a rigid plate drawn broadside through water (after Ahlborn).

a



b

EXPLANATION OF PLATE XXVI

a *Island hill* of granite in sand tenne, near Jebel Gerri station, Khartum district.

b Other island hills near Jebel Gerri station. Note desert vegetation.

PLATE XXVI

a

b

INDEX.

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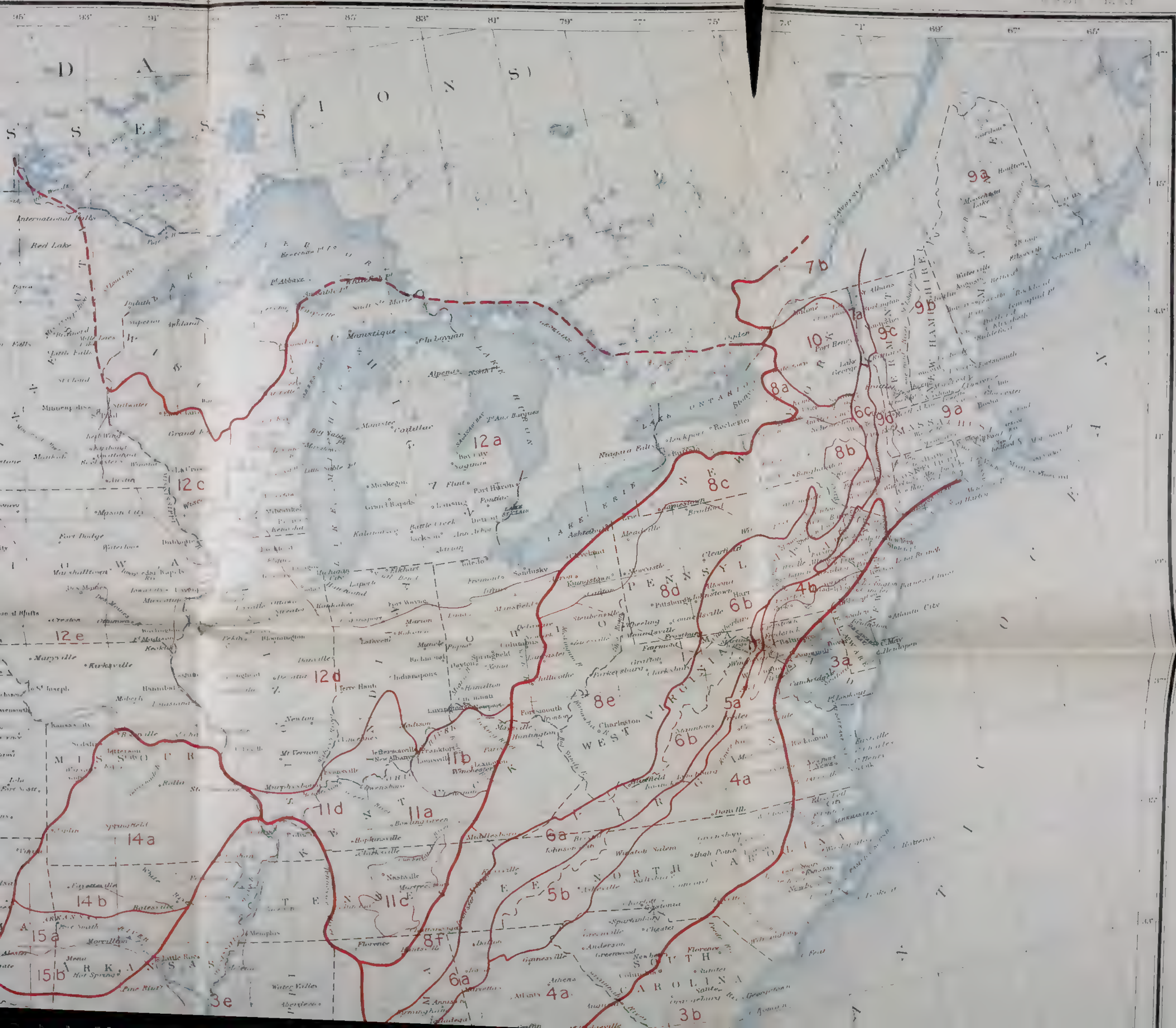
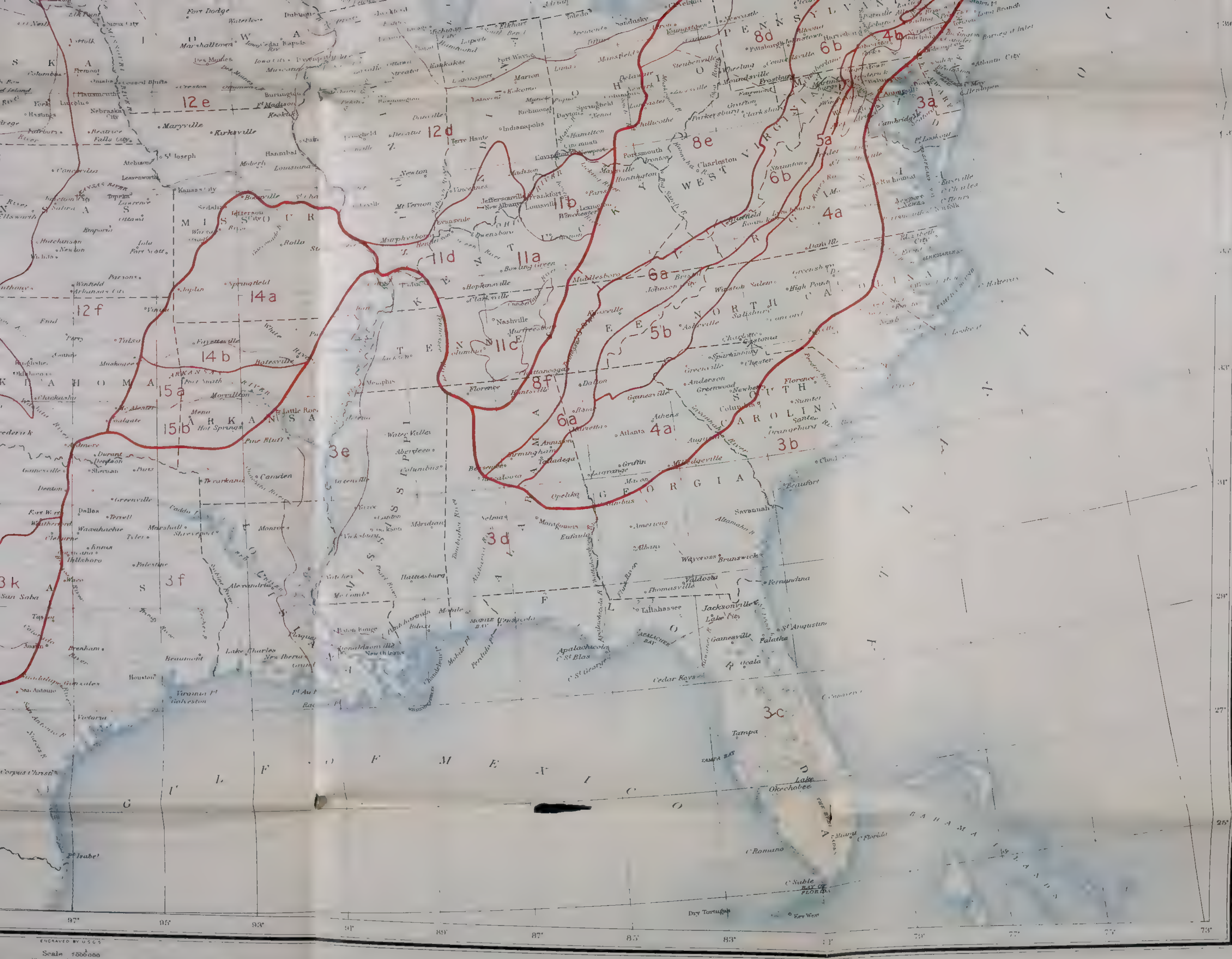
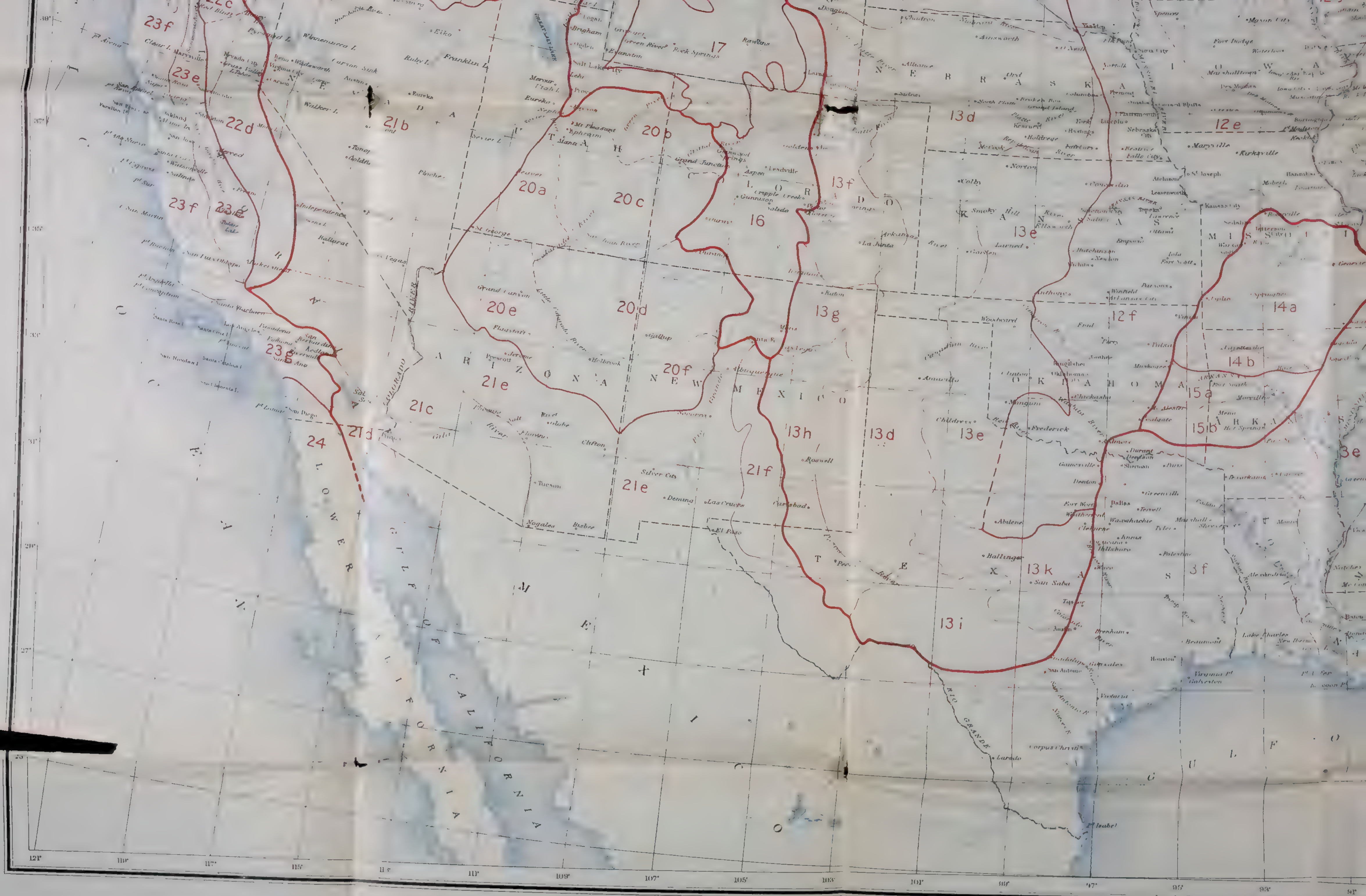




NOTE. Major divisions are separated by the broadest lines.
Provinces are distinguished by number.
Sections are indicated by letter.
Numbers and letters correspond to those on table pp. 30-35.



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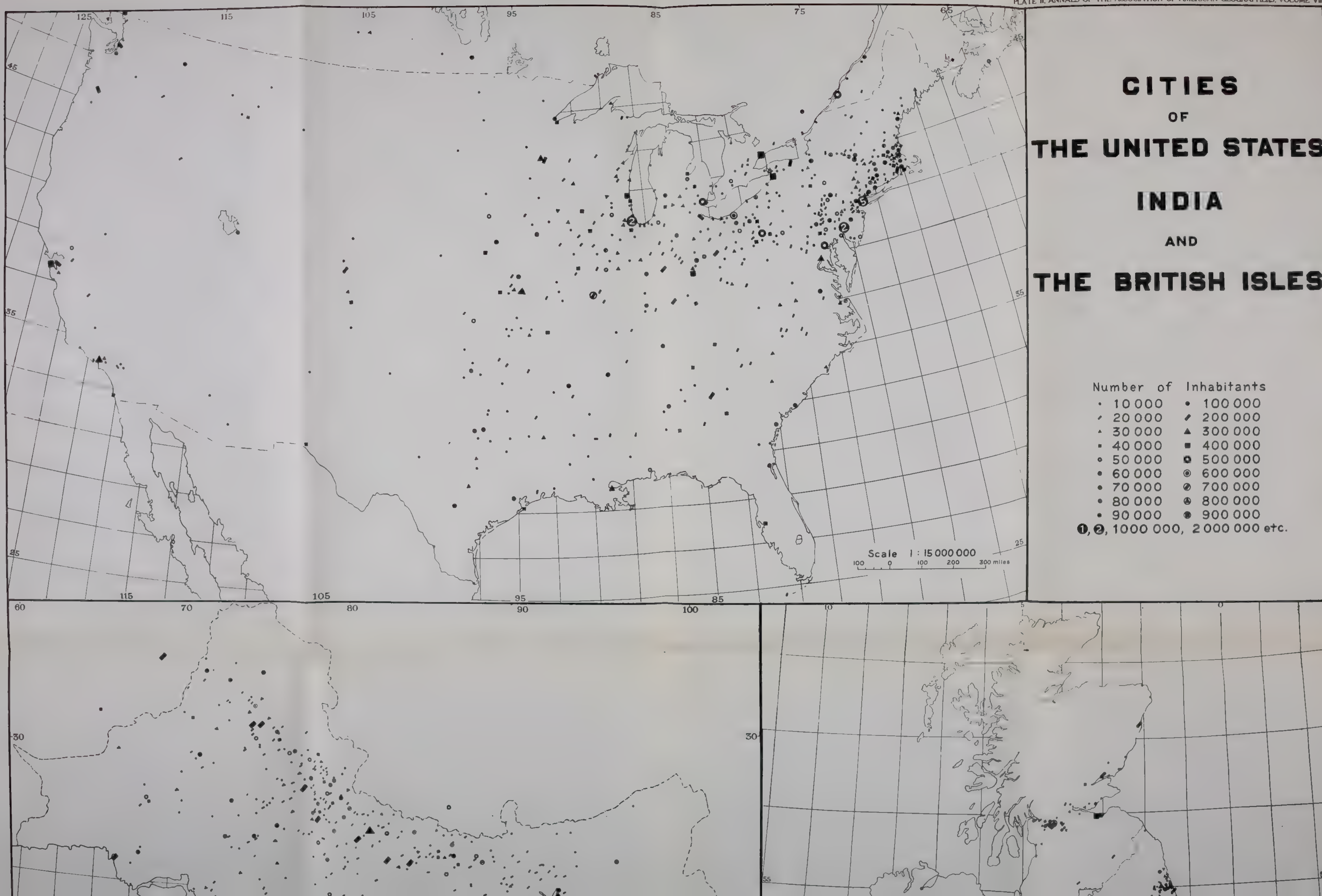
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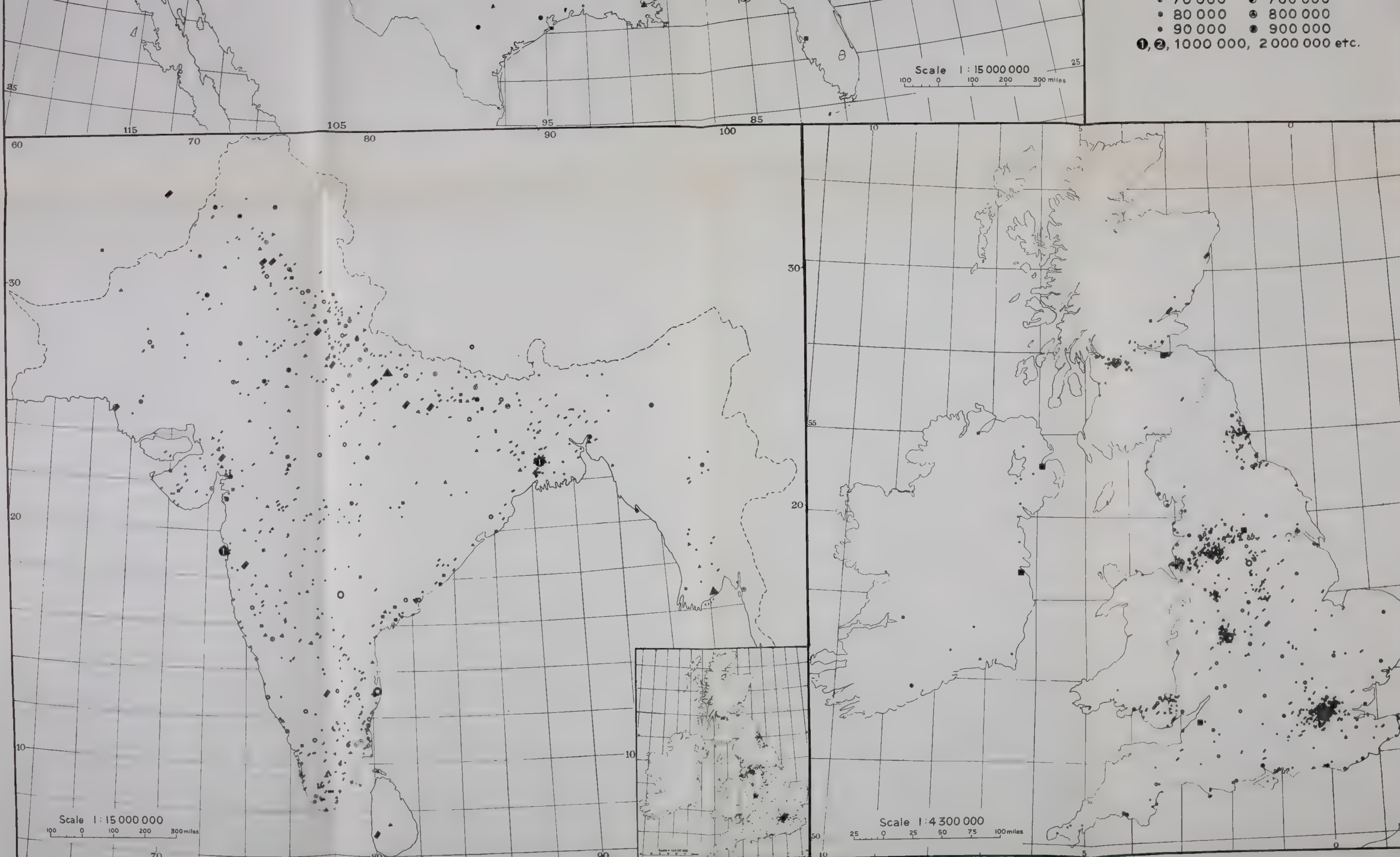
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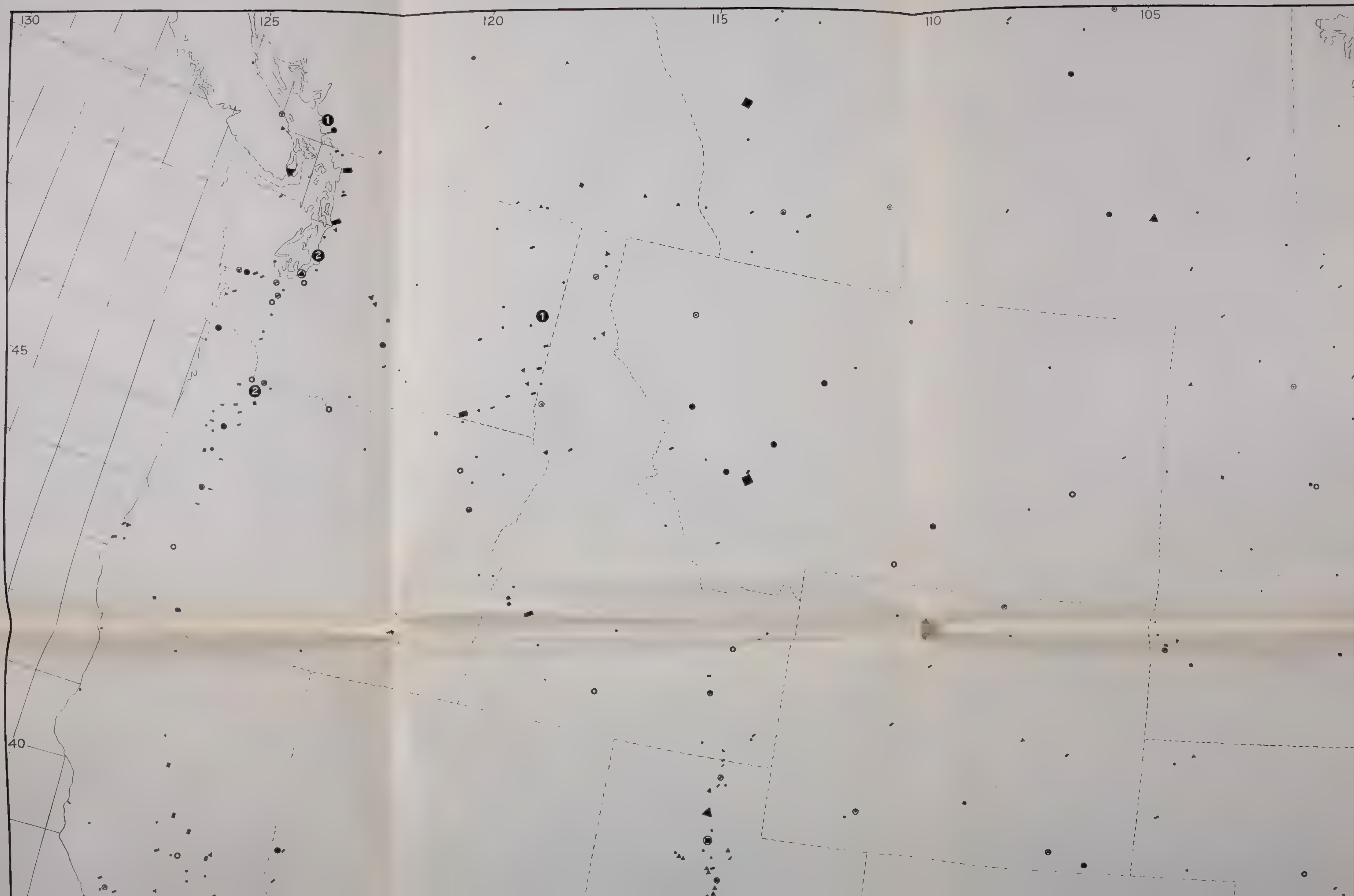
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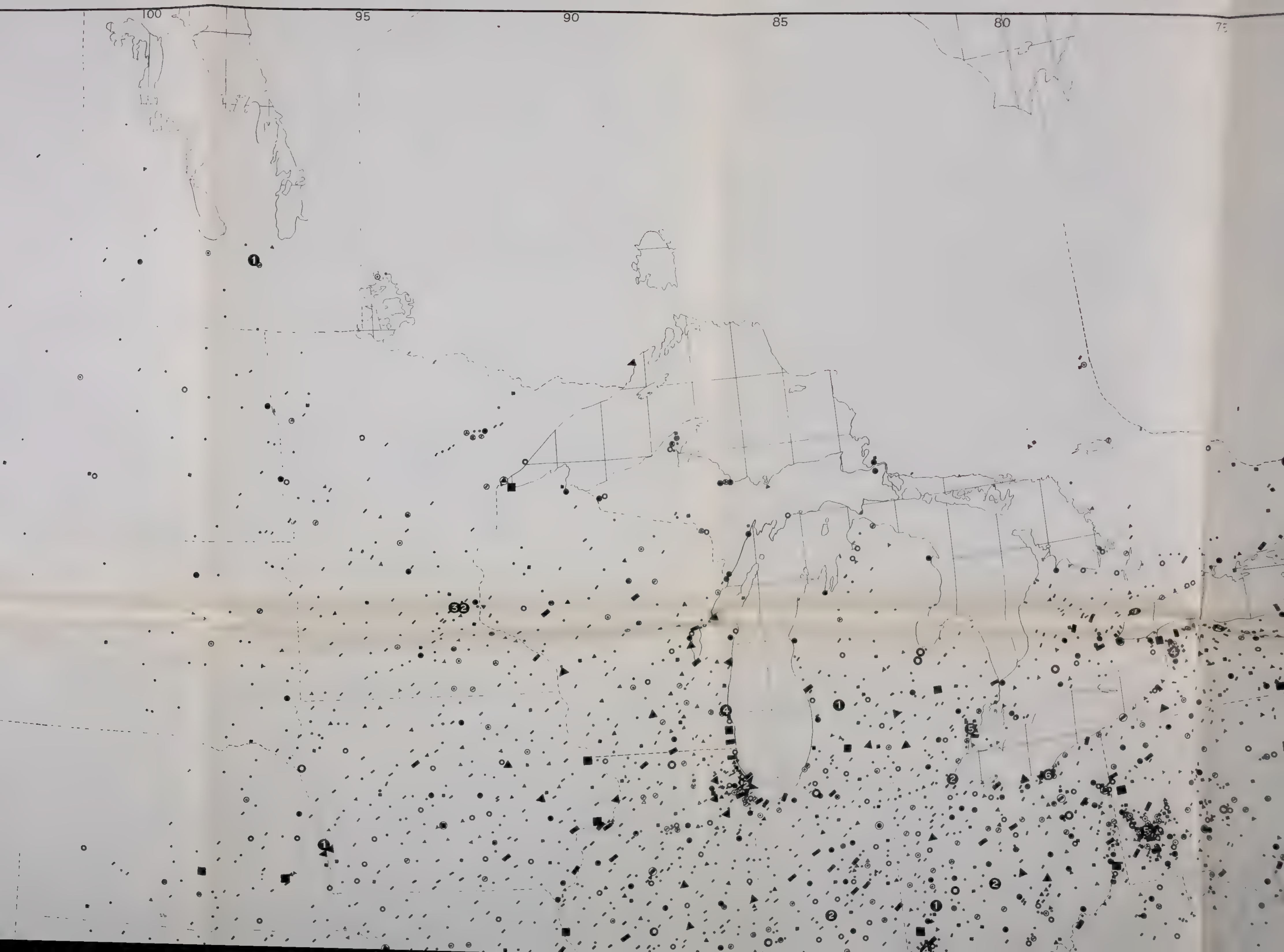
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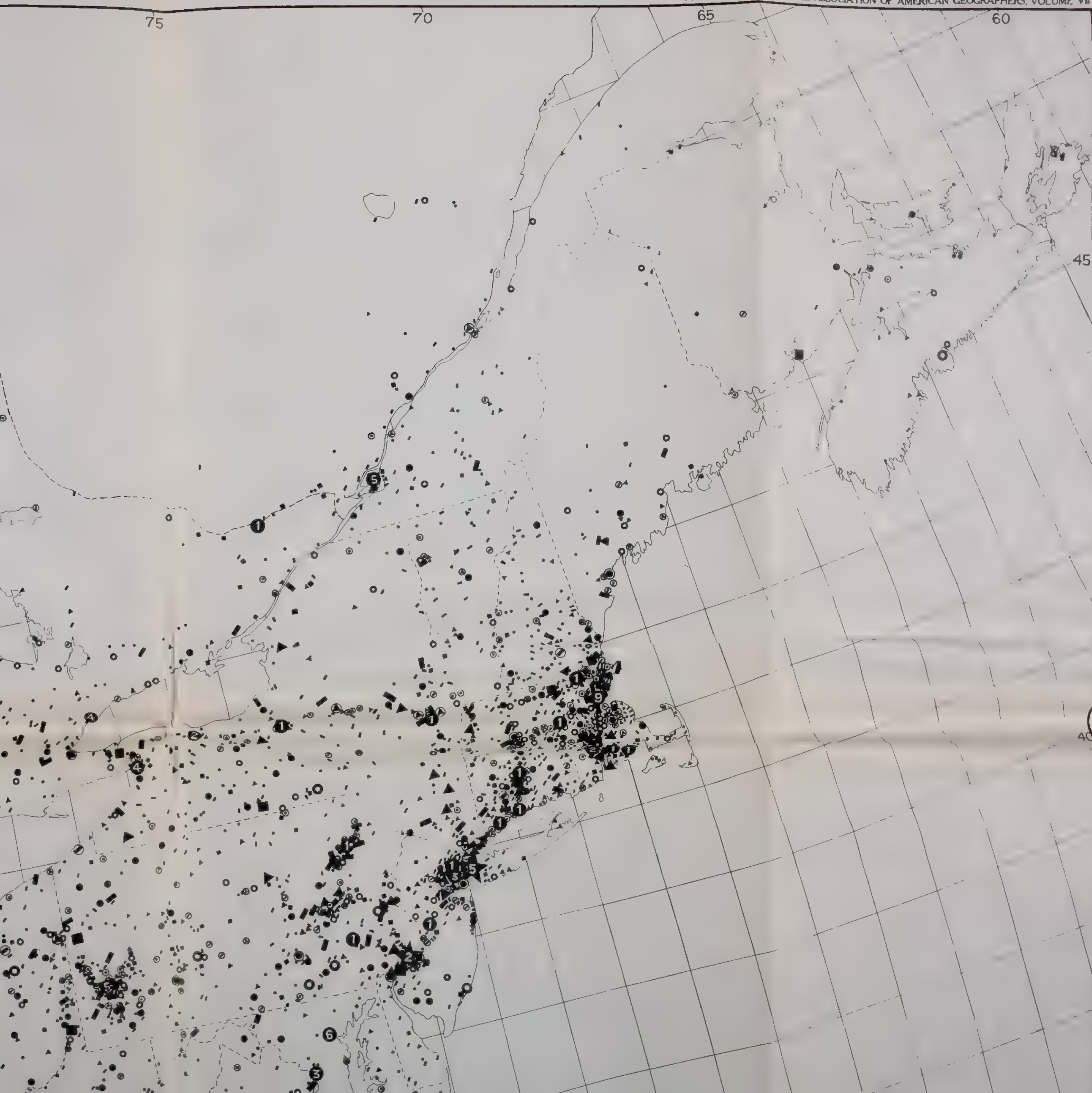
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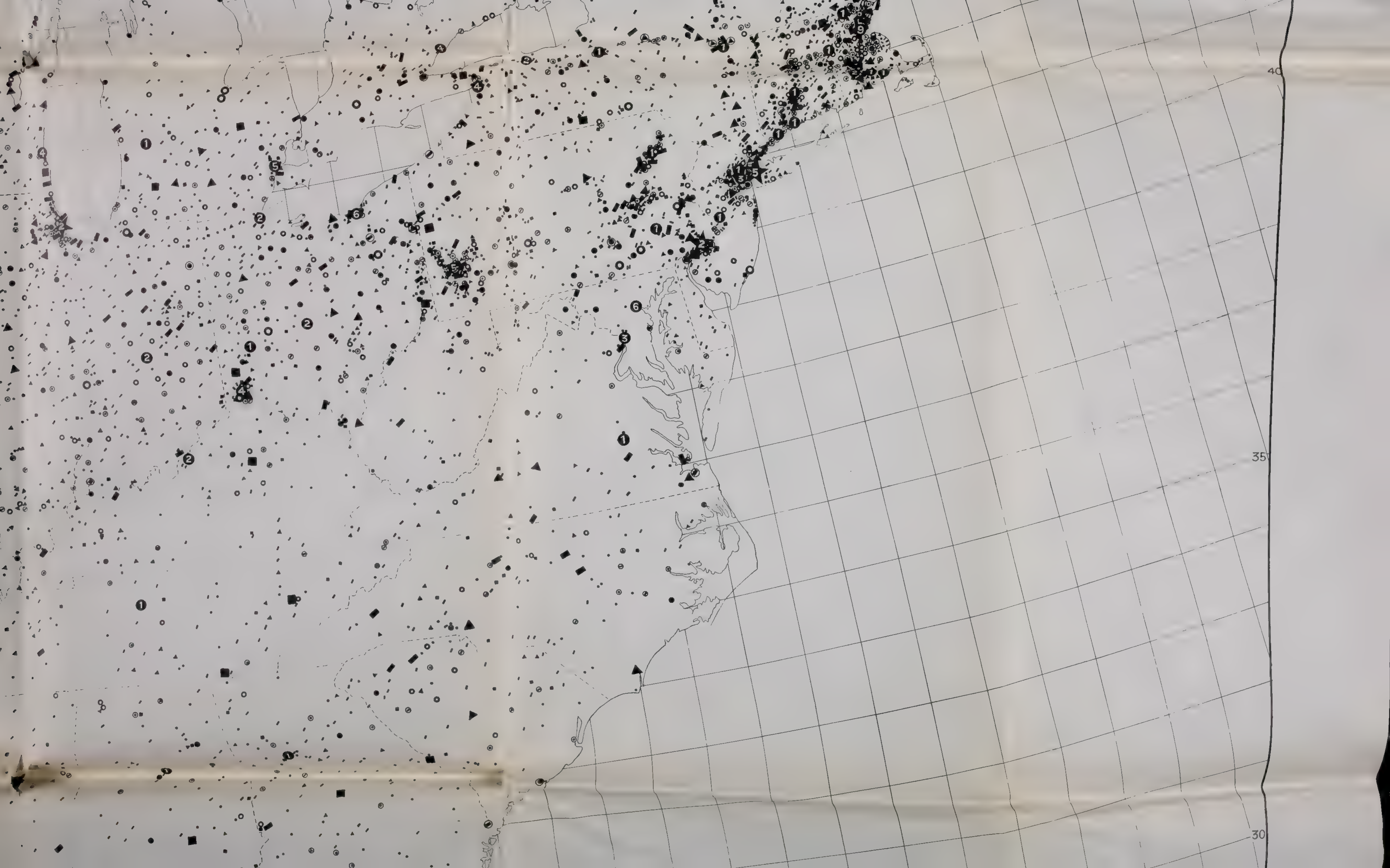
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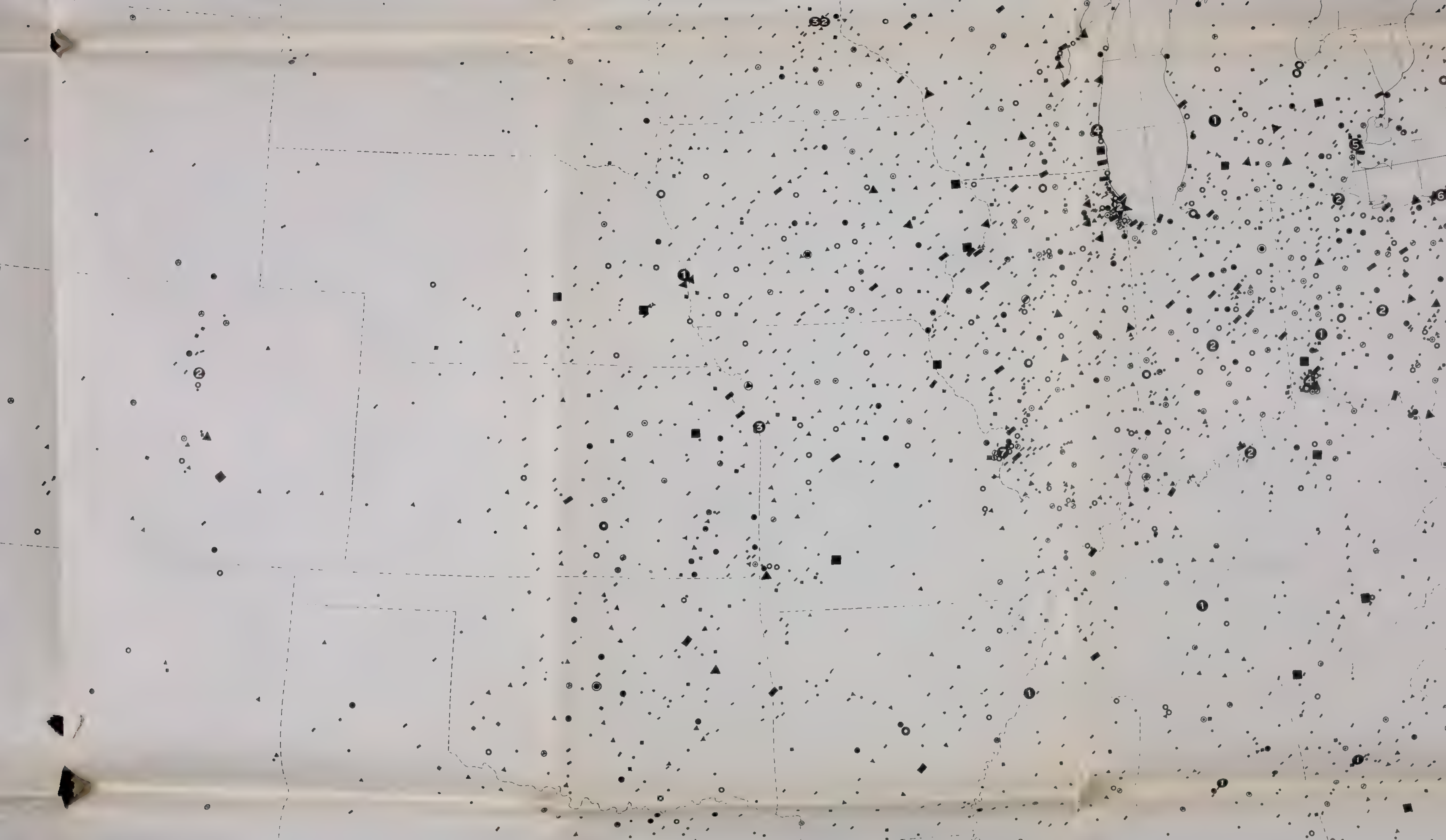

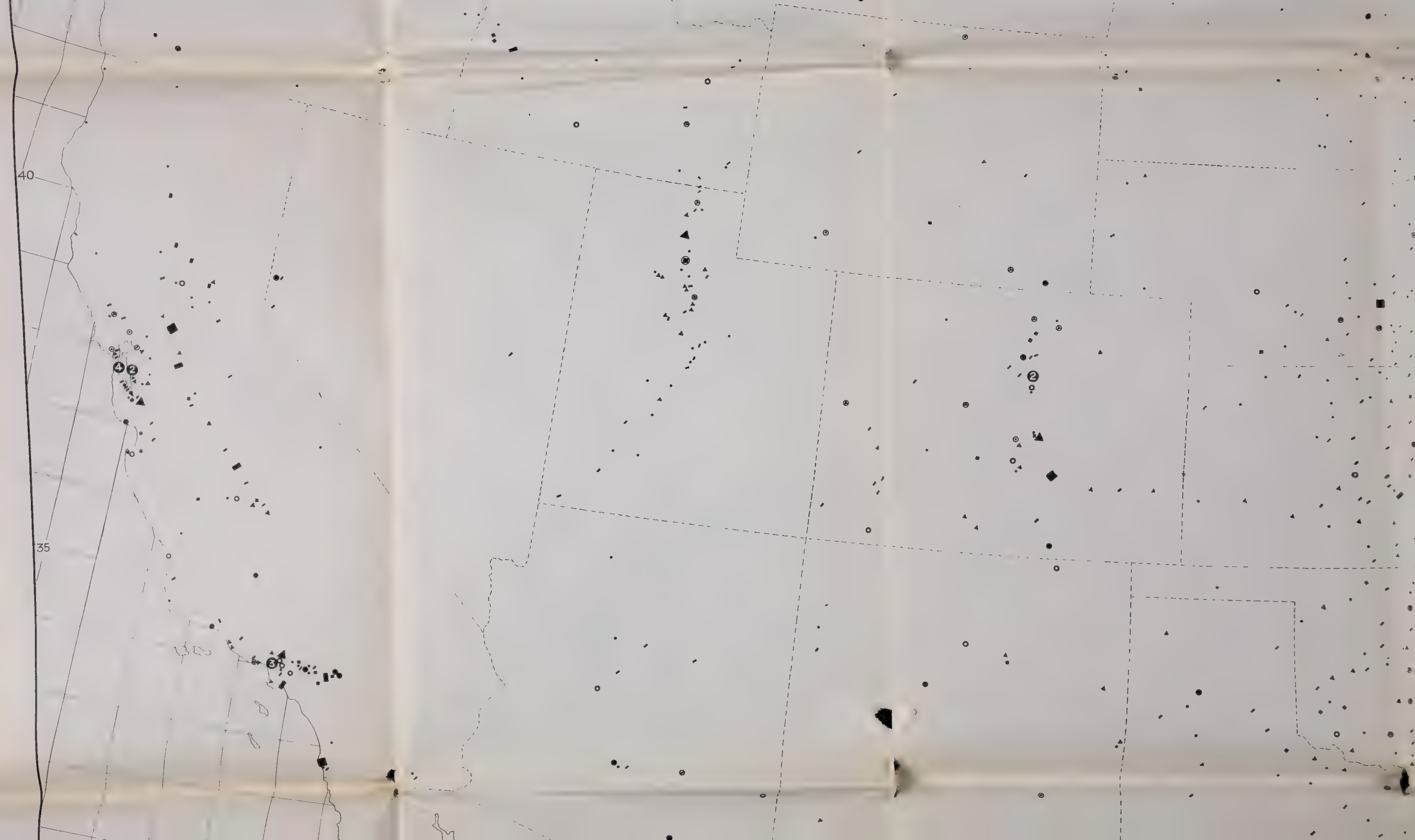

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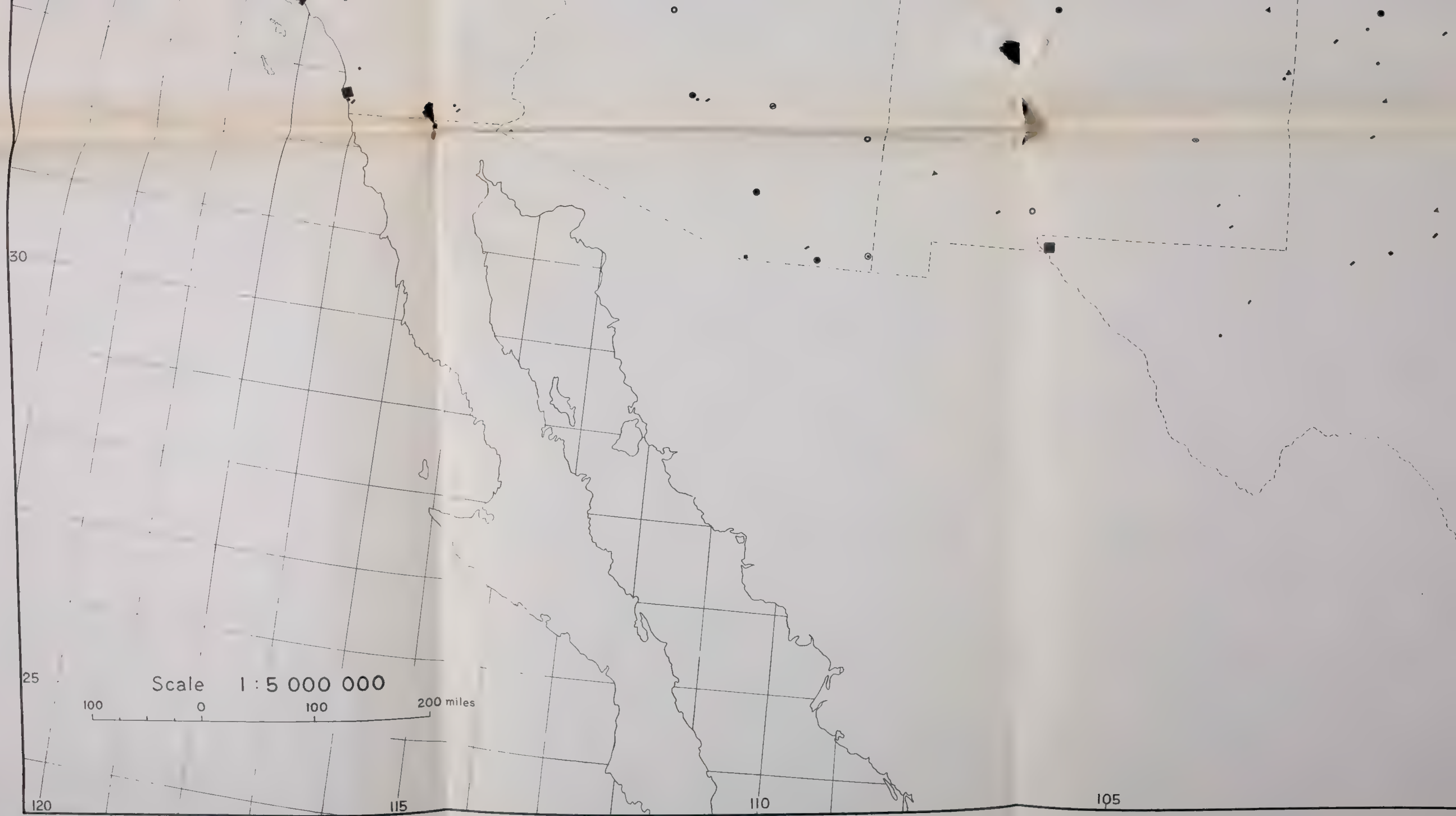

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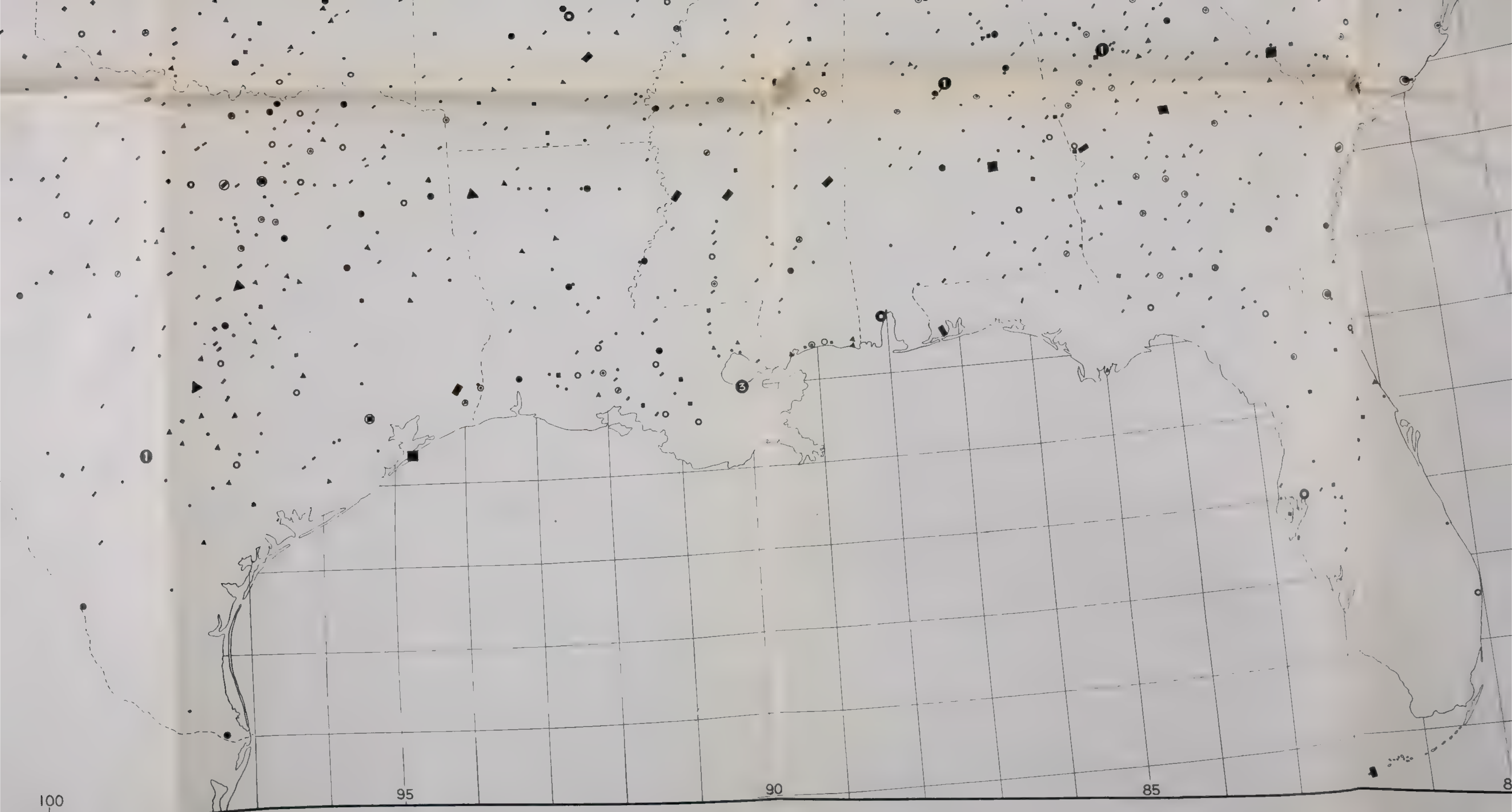

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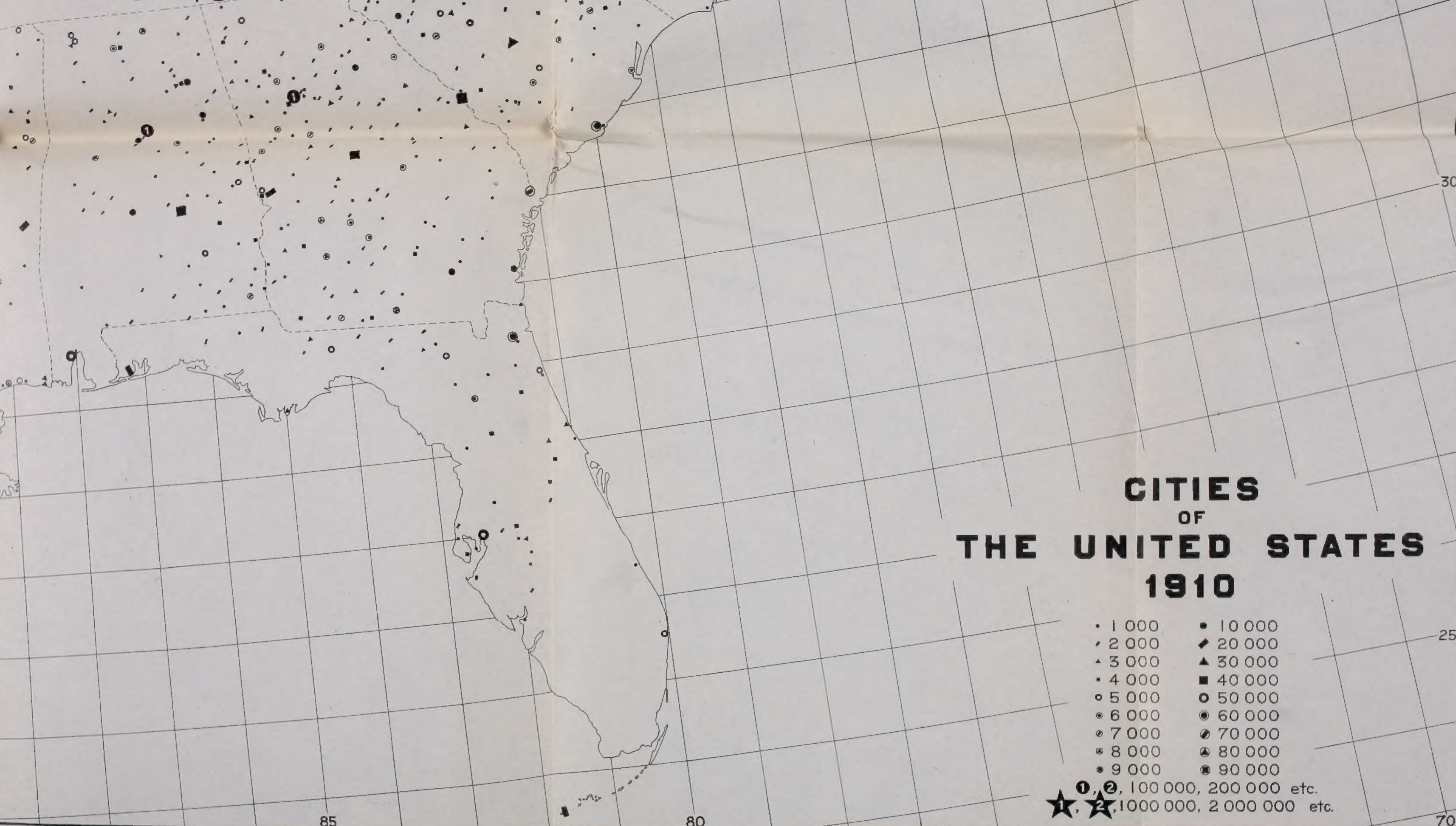
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